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Memorandum To MR. R.A. SOGAWA
Manager, Route & Site Planning
Design and Development - Transmission

Date July 15, 1986

Location or Dept H8A9

File 837.2211 (P)

Subject **Research Division Report 86-154-K**
"Transmission Lines and Ozone
Concentrations in Southwestern Ontario"

The attached report describes a study of the ozone concentrations to be expected, as a result of the operation of the 500 kV transmission lines proposed for Southwestern Ontario, which we undertook for your Department. As you will notice, we made a number of conservative assumptions about the transmission lines in arriving at the expected mean ozone concentrations. In spite of this, the proposed transmission lines were estimated to lead to no more than a 0.1% addition to the mean ozone concentrations now occurring in this part of Ontario. The year-to-year variability of mean ozone concentrations is at least two orders of magnitude larger than the calculated contribution from the proposed lines.

The results confirm the feelings we had even before we started the study, that ozone from transmission lines and its impact on agricultural crops is a "red-herring" The Foodland Hydro Committee should be asked to justify their concern.

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EXECUTIVE SUMMARY

TRANSMISSION LINES AND OZONE CONCENTRATIONS IN SOUTHWESTERN ONTARIO

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Ontario Hydro has proposed new transmission facilities in Southwestern Ontario to connect the electricity generating power plants at Bruce and Nanticoke to the load centres in the Province. The new facilities include two 500-kV transmission lines (Bruce-to-London and London-to-Nanticoke) which would run through highly productive agricultural land. This, plus the fact that high voltage transmission lines produce small amounts of ozone, led the Foodland Hydro Committee to express concern about the effect of transmission line-induced ozone on crop yields. The ozone concentrations to be expected from the operation of the two transmission lines were thus calculated so that crop yield losses could be assessed by others.

The approach used in calculating ozone concentrations involved using PAL, a steady-state Gaussian plume model developed by the US Environmental Protection Agency; meteorological data observed at Goderich, London and Simcoe; ozone production rates based on extensive corona loss measurements made by Ontario Hydro and published corona ozone yields; and other details of the proposed transmission lines. Calculations were made for the time of year when crops are most sensitive (May 1 - September 30, and 0900-1600 hours) and 3 years, 1978-80.

The calculated seasonal average ozone concentrations were found to be less than 0.03 parts per billion when both transmission lines were assumed to be double-circuit. The case where the London-to-Nanticoke transmission line is assumed to be single-circuit was also run and the calculated seasonal average ozone concentration was found to be less than 0.02 parts per billion. These values are less than 0.1% of the ozone concentrations which now occur in Southwestern Ontario (30-55 parts per billion).

job	file	date	report no.
740635-116-491	837.2211	July 21, 1986	86-154-K

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TRANSMISSION LINES AND OZONE CONCENTRATIONS IN SOUTHWESTERN ONTARIO

Y.T. Tam, O.T. Melo

ABSTRACT

The ozone concentrations that may result from operation of the proposed Southwestern Ontario transmission lines were calculated using PAL, a Gaussian dispersion model developed by the US Environmental Protection Agency, and 1978-80 weather data from Goderich, London and Simcoe. Results indicate that the concentrations at the ground near the lines depend highly on weather conditions. However, when this variability is averaged over the period when agricultural crops are most sensitive (May 1 to September 30, 0900 to 1400 hours), the concentrations due to the transmission lines are quite low (less than 0.03 parts per billion), compared with the ozone concentrations which now occur in Southwestern Ontario (30-55 parts per billion).

INTRODUCTION

Ontario Hydro has proposed new transmission facilities in Southwestern Ontario to connect the electricity generating facilities at Bruce and Nanticoke to the load centres in the Province. The new facilities include 500 kV transmission lines from Bruce-to-Essa TS, Bruce-to-London and London-to-Nanticoke.

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Small quantities of ozone will be produced by the proposed transmission lines. This has led the Foodland Hydro Committee to express concern regarding the potential effect of transmission line-induced ozone on crop yields in the highly productive farmlands affected by the proposed Bruce-to-London and London-to-Nanticoke facilities. A cursory assessment of transmission line-induced ozone and the corresponding effects on crop yields was previously carried out for a 500 kV, single-circuit line (see "A Review of the Effects of Transmission Line-Induced Ozone on Agricultural Crops," 1984). To address the Committee's concerns more thoroughly, Ontario Hydro has carried out a comprehensive investigation of the ozone concentrations to be expected as a result of the operation of the 500 kV, single- and double-circuit transmission facilities. This report is a summary of the findings for the Bruce-to-London and London-to-Nanticoke facilities.

In order to assess the significance of transmission lines as a source of ozone, the following information is needed:

- o details of the design of the line (number of circuits, voltage, conductor height and size, location),
- o knowledge of the amount of corona loss and ozone formation under various weather conditions,
- o weather information for the area traversed by the lines,
- o a means of calculating ozone concentrations at the ground, and
- o typical ozone concentrations now occurring in Southwestern Ontario, to be used as a reference against which to compare the contribution of the lines.

The standard 500 kV, single- or double-circuit line designs were assumed and the extensive measurements made on lines of this type were used to set values of corona loss under two types of weather - fair and foul. Published values of the ozone formation for given corona losses were used to calculate the amount of ozone generated by the lines. Weather information for three years (1978-1980) and three stations (Goderich, London and Simcoe) was obtained from Environment Canada. A dispersion model developed by the US Environmental Protection Agency was used to calculate ozone concentrations at the ground in the vicinity of the proposed lines during the period when crops are most sensitive (May 1 to September 30 and 0900 to 1600 hours). Finally, representative ambient ozone measurements made by the Ontario Ministry of the Environment were used for comparison against the calculated line contributions.

THE LOCATION AND DESIGN OF THE PROPOSED TRANSMISSION FACILITIES

The proposed transmission facilities in Southwestern Ontario include:

- one 500 kV, single-circuit transmission line between Bruce and Essa TS;
- a new 500/230 kV transformer station and associated facilities in Caradoc Township (west of London), together with 230 kV connections into the existing 230 kV system;
- one 500 kV, double-circuit transmission line between Bruce and a new transformer station in the London area, and
- one 500 kV, single-circuit transmission line between the new transformer station and Nanticoke.

These transmission facilities, referred to as Plan 7, are described in more detail in "Southwestern Ontario Transmission Study Environmental Assessment - Summary" (Ontario Hydro Design and Development - Transmission Report 85069). For the purposes of the present assessment, the general layout of the transmission facilities is outlined in Figure 1.

As mentioned in the Introduction, the Bruce-to-London and London-to-Nanticoke transmission lines are of particular interest to the Foodland Hydro Committee. In what follows, the Bruce-to-London transmission line will be modelled as a long straight line running from north to south and the London-to-Nanticoke transmission line as a long straight line running 15° northeast of west to east. It will be further assumed that both transmission lines are of the 500 kV, double-circuit design, a conservative assumption in the London-to-Nanticoke case, where a single-circuit transmission line is planned. The degree of conservatism involved in this assumption will be tested by performing a few calculations with a single-circuit transmission line.

As proposed, the conventional lattice four-footing tower will be used for most locations. Sketches of the single- and double-circuit tower designs, showing the important dimensions of conductor height and spacing, are presented in Figure 2.

CORONA PROCESSES AND OZONE FORMATION

Corona Processes

Corona activity, that is the electrical breakdown of air, occurs at imperfections and protrusions on the surface of conductors.

FIGURE 1

GENERAL LAYOUT OF THE TRANSMISSION FACILITIES
PROPOSED FOR SOUTHWESTERN ONTARIO

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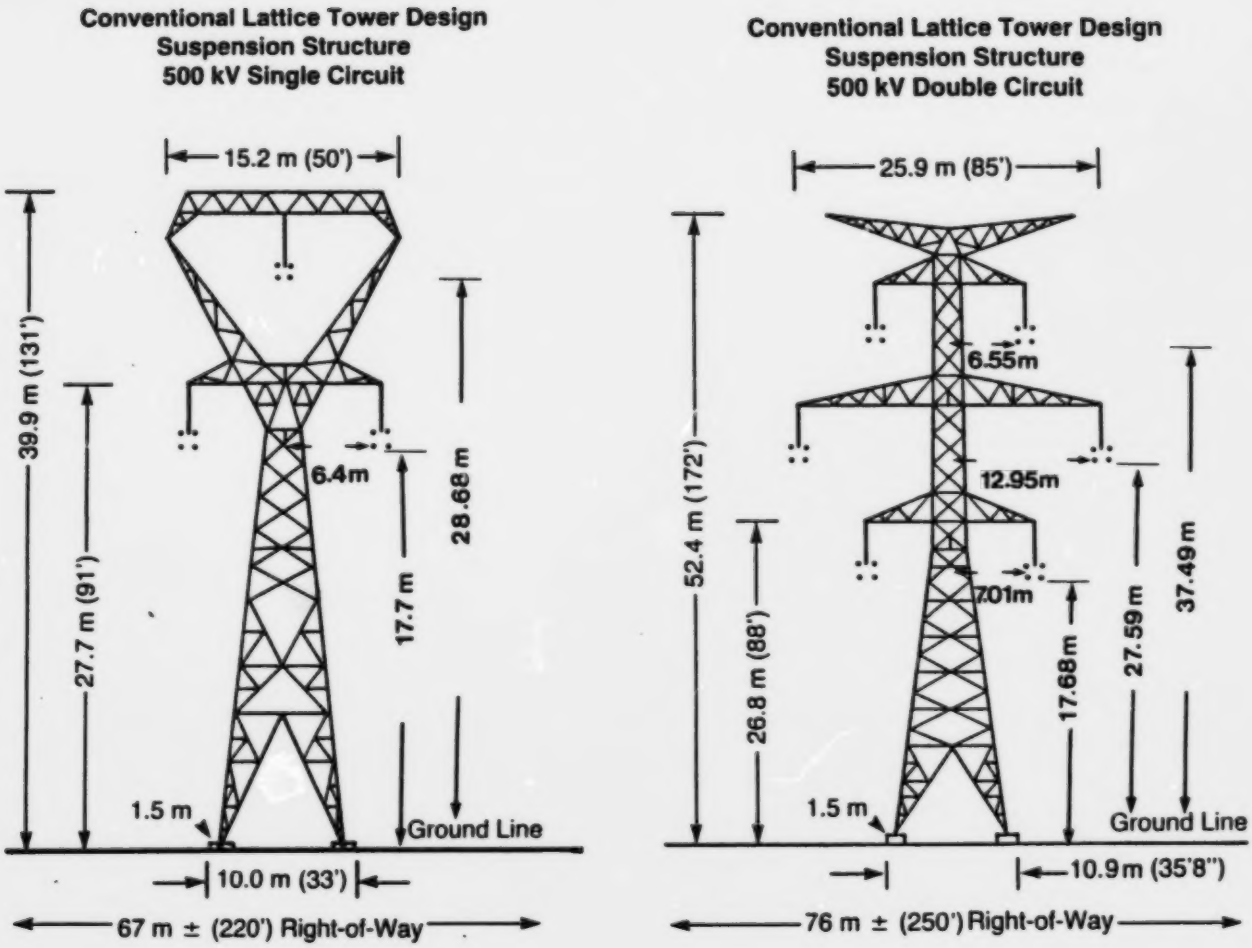

FIGURE 2

TWO OF THE TOWER DESIGNS TO BE USED IN THE TRANSMISSION FACILITIES PROPOSED FOR SOUTHWESTERN ONTARIO

The electrical field gradient at these imperfections and protrusions may rise to a point which causes ionization of the air in the vicinity of the conductor. Any process which leads to increases in the number of these imperfections and protrusions or results in higher electrical field gradients will be accompanied by higher corona losses.

Natural protrusions may be in the form of condensation droplets, raindrops and snow and ice crystals which adhere to the conductors and are responsible for the marked increase in corona activity observed during foul weather. Conductor imperfections result from handling during transportation and stringing operations. Dust deposits on the conductors provide additional sites for corona activity.

Electrical field gradients may be increased by increasing the conductor voltage, decreasing the conductor diameter and decreasing the phase spacing or conductor height. When bundled conductors are used, the subconductor spacing is another variable affecting corona loss.

During the 1950's and early 60's, Ontario Hydro carried out extensive tests of corona losses from experimental transmission lines, consisting of bundled conductors, operated under a variety of weather conditions and voltages (Nigol and Cassan, 1961). Results from these tests for 500 kV, double-circuit transmission line configurations, of the type proposed for Southwestern Ontario, are reproduced in Figure 3. Corona loss is seen to be strongly dependent on precipitation intensity. For simplicity, a conservative upper limit value of 180 J/m.s will be used for corona loss under foul weather conditions (rain, snow and fog). A much smaller value of 2 J/m.s will be used for fair weather conditions. These values should be halved for single-circuit transmission lines.

Ozone Formation

Conductors in corona provide a source of electrons which may interact with the surroundings. In air, ozone may result from such interactions. One mechanism that has been proposed involves the excitation and subsequent dissociation of oxygen molecules (see Melo, 1976 and references therein):

$$O_2 + e^- \text{-----} > 2O^* + e^- \qquad (1)$$

The oxygen radicals will then react with oxygen forming ozone:

$$O^* + O_2 + M \text{-----} > O_3 + M \qquad (2)$$

Here M is a third molecule in this termolecular reaction step. Nitrogen, water vapour and oxygen are likely to be involved in this role.

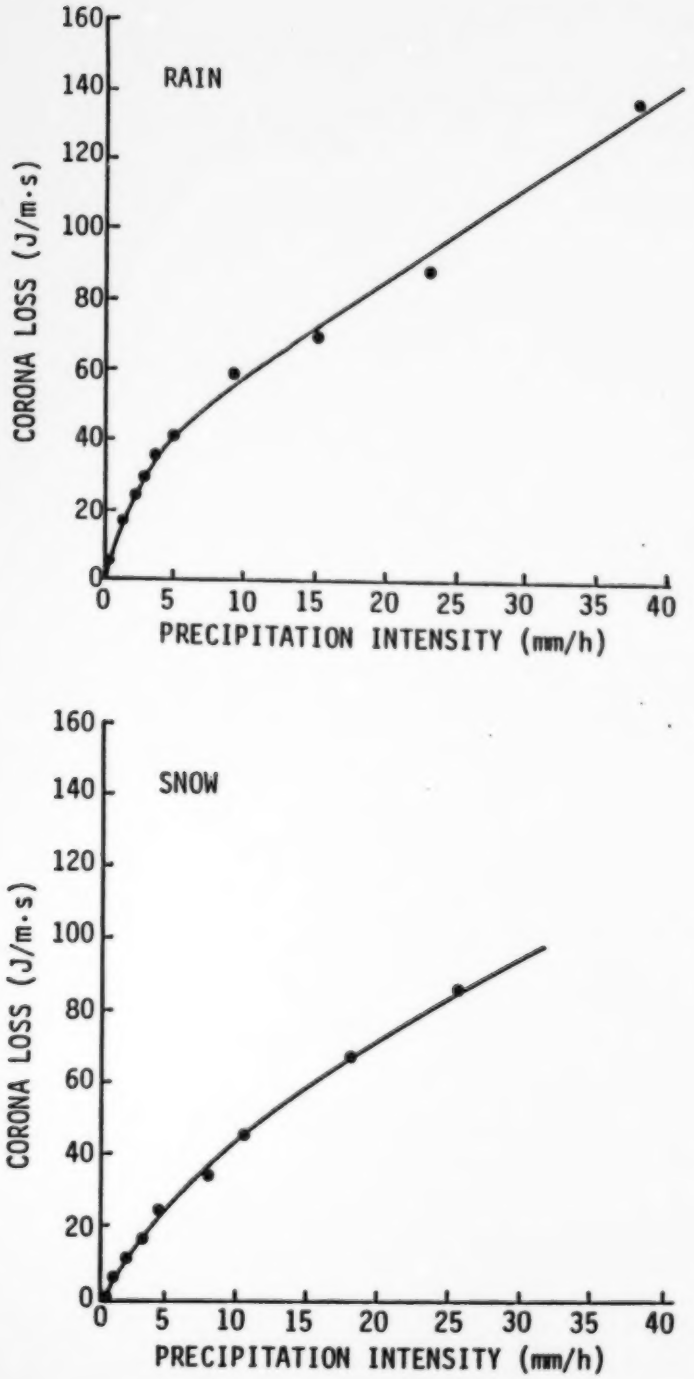

FIGURE 3

CORONA DISCHARGE AS A FUNCTION OF RAIN AND SNOW INTENSITY FOR A 500 KV DOUBLE-CIRCUIT TRANSMISSION LINE (AFTER NIGOL AND CASSAN, 1961)

Ozone destruction in the corona region may also take place. The following are three possible destruction steps:

$$O + O_3 \text{ -----> } 2O_2 \quad (3)$$

$$e^- + O_3 \text{ -----> } O_2 + O + e^- \quad (4)$$

$$NO + O_3 \text{ -----> } O_2 + NO_2 \quad (5)$$

In a previous review (Melo, 1976), it was found that the ozone production efficiency of corona discharges has generally been determined from simultaneous measurements of corona losses and resulting ozone concentrations in the air circulated over experimental, laboratory-size test conductors. Laboratory conditions were, for the most part, used to make these measurements, although some attempts were made to simulate the effects of rain, high relative humidity and dust deposits on the conductors. The ozone production efficiency was shown to depend on parameters, such as the number of conductors in the bundle, the conductor size, moisture content of the atmosphere and the presence of foreign material on the conductor surface. When only the measurements made with conductors of the design proposed for the Southwestern Ontario transmission facilities are considered, it is found tht the ozone production efficiency is about 0.4 µg/J (Melo, 1976; Roach et al, 1974). This value will be used here for both fair and foul weather conditions.

Given the corona discharge rate, L, (J/m.s) and the ozone production efficiency, E (µg/J), the ozone source strength, Q (µg/m.s), of the proposed transmission lines can be calculated from:

$$Q = L \times E \quad (6)$$

The source strengths are:

	Source Strength, µg/m.s	
	Fair Weather	Foul Weather
Double-Circuit	0.8	72
Single-Circuit	0.4	36

DISPERSION MODEL

The concentration of ozone produced by the transmission lines, at some specific receptor locations, was calculated using a Gaussian dispersion model developed by the US Environmental Protection Agency. The model, known as PAL, is designed for determining the concentrations of non-reactive pollutants from multiple sources (Point, Area and Line) under various weather conditions. The model can consider up to six types of sources, ie, point, area, horizontal line, horizontal curved, specialized line and specialized curved sources. The following assumptions are made in the model:

- Dispersion from points and area and line elements results in Gaussian distributions in both the horizontal and vertical directions and, therefore, steady-state Gaussian plume equations can be used for point sources and, the integration of these equations, for line and area sources.

- Concentration estimates may be made for each hourly period using the mean meteorological conditions appropriate for each hour.

- The total concentration at a receptor is the sum of the concentrations estimated from all point and area sources, that is, concentrations are additive.

In the present study, the Bruce-to-London and London-to-Nanticoke transmission lines can be treated as typical horizontal line source dispersion cases. The concentration from a line source, χ ($\mu g/m^3$), is given by

$$\chi = \frac{Q}{u} \int_0^D F \, d\ell \qquad (7)$$

where Q is the source strength ($\mu g/m.s$) discussed in the previous section, u is the wind speed (m/s), ℓ is a length element (m), D is the total length of the line source (m), and F is the point source dispersion function.

The expression for the point source dispersion function depends upon atmospheric stability. For stable conditions

$$F = \frac{1}{2\pi\sigma_y\sigma_z} \exp\left[-\frac{y^2}{2\sigma_y^2}\right] \cdot \left\{\exp\left[-\frac{(z+h)^2}{2\sigma_z^2}\right] + \exp\left[-\frac{(z-h)^2}{2\sigma_z^2}\right]\right\} \qquad (8)$$

Here, σ_y and σ_z are standard deviations (m) of particle position in the horizontal and vertical direction, respectively; y is the crosswind distance (m); z is the vertical distance (m); and h is the effective height of emission (m). Figure 4 shows the line source and receptor relationships which define x, needed to calculate σ_y and σ_z, and y used in equations 8,9 and 10 (see below).

In unstable or neutral conditions, when σ_z is greater than 1.6 times the mixing height, H (m),

$$F = \frac{1}{\sqrt{2\pi}\, H\sigma_y} \exp\left[-\frac{y^2}{2\sigma_y^2}\right] \qquad (9)$$

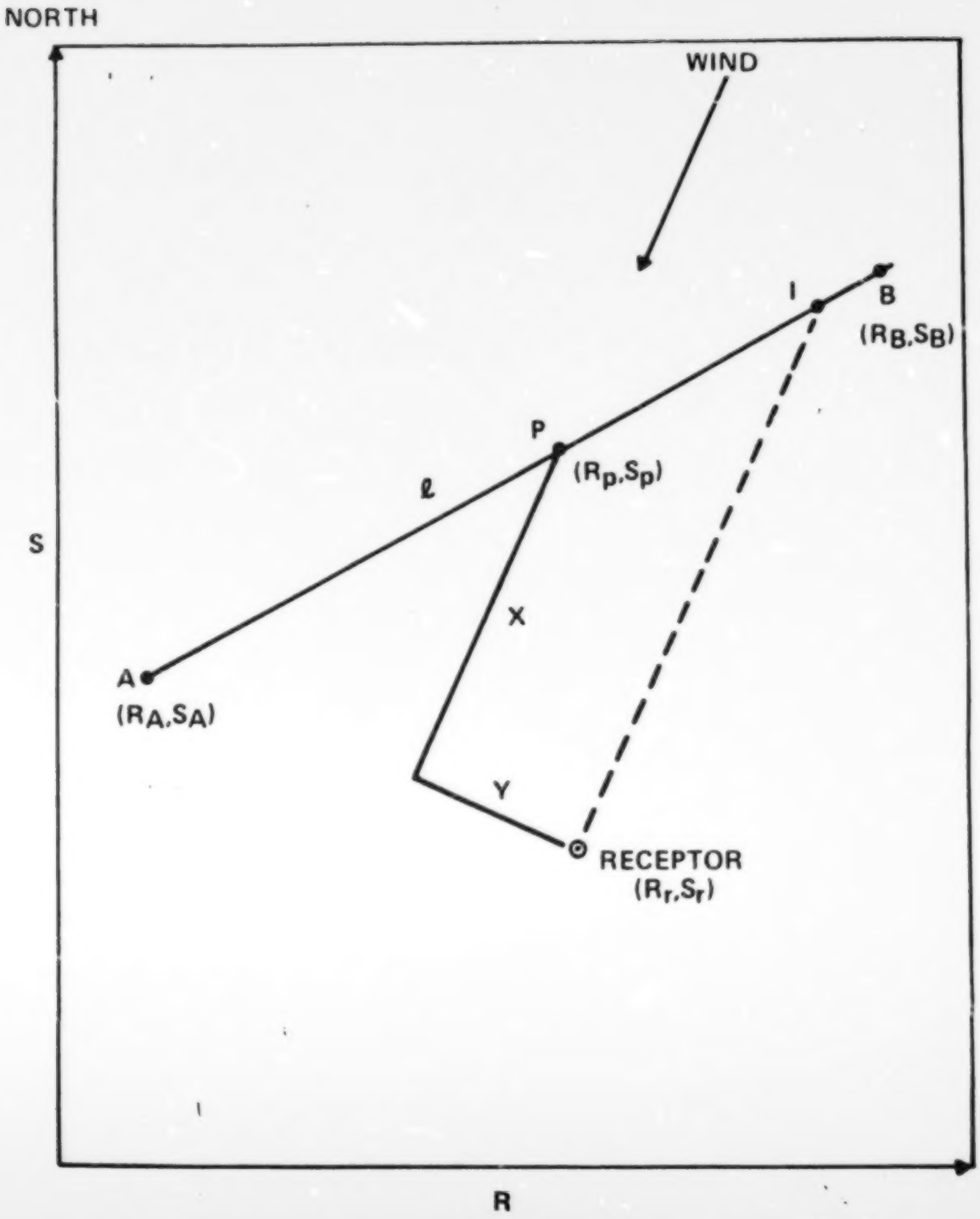

FIGURE 4

LINE SOURCE AND RECEPTOR
RELATIONSHIPS USED IN PAL

This expression implies that under this condition the distribution of concentrations below the mixing height is uniform with height regardless of source or receptor height, provided both are less than the mixing height. In all other unstable or neutral conditions

$$F = \frac{1}{2\pi\sigma_y\sigma_z} \exp\left[-\frac{y^2}{2\sigma_y^2}\right] G \qquad (10)$$

where

$$G = \sum_{N=-\infty}^{\infty} \left\{\exp\left[-\frac{(z+h+2NH)^2}{2\sigma_z^2}\right]+\exp\left[-\frac{(z-h+2NH)^2}{2\sigma_z^2}\right]\right\} \qquad (11)$$

Details of the method of solution of these equations have been presented by Turner and Petersen (1975) and Petersen (1978).

METEOROLOGICAL DATA

As discussed in the previous section, the PAL model requires the following meteorological information for the areas traversed by the proposed transmission lines:

- o wind speed and direction,
- o standard deviations of particle position, and
- o mixing height.

Environment Canada operates a number of meteorological stations in Southwestern Ontario. Three of these, Goderich, London and Simcoe (see Figure 5), were selected for the present calculations. Goderich is representative of conditions towards the middle to north end of the Bruce-to-London line (at one point, the proposed transmission line route comes within 5 km of the Goderich weather station); London is representative of conditions around the London end of the two transmission lines; and Simcoe is representative of conditions at the eastern end of the London-to-Nanticoke transmission line.

Weather data were selected to reflect the exposure period used by the National Crop Loss Assessment Network (NCLAN) in assessing seasonal crop loss response to ambient ozone concentrations. Hourly data for the 7-hour period from 0900 to 1600, throughout the growing season from May 1 to September 30, were thus used in the analysis.

According to Environment Canada, the Goderich and Simcoe stations became automatic in late 1980 and 1983, respectively.

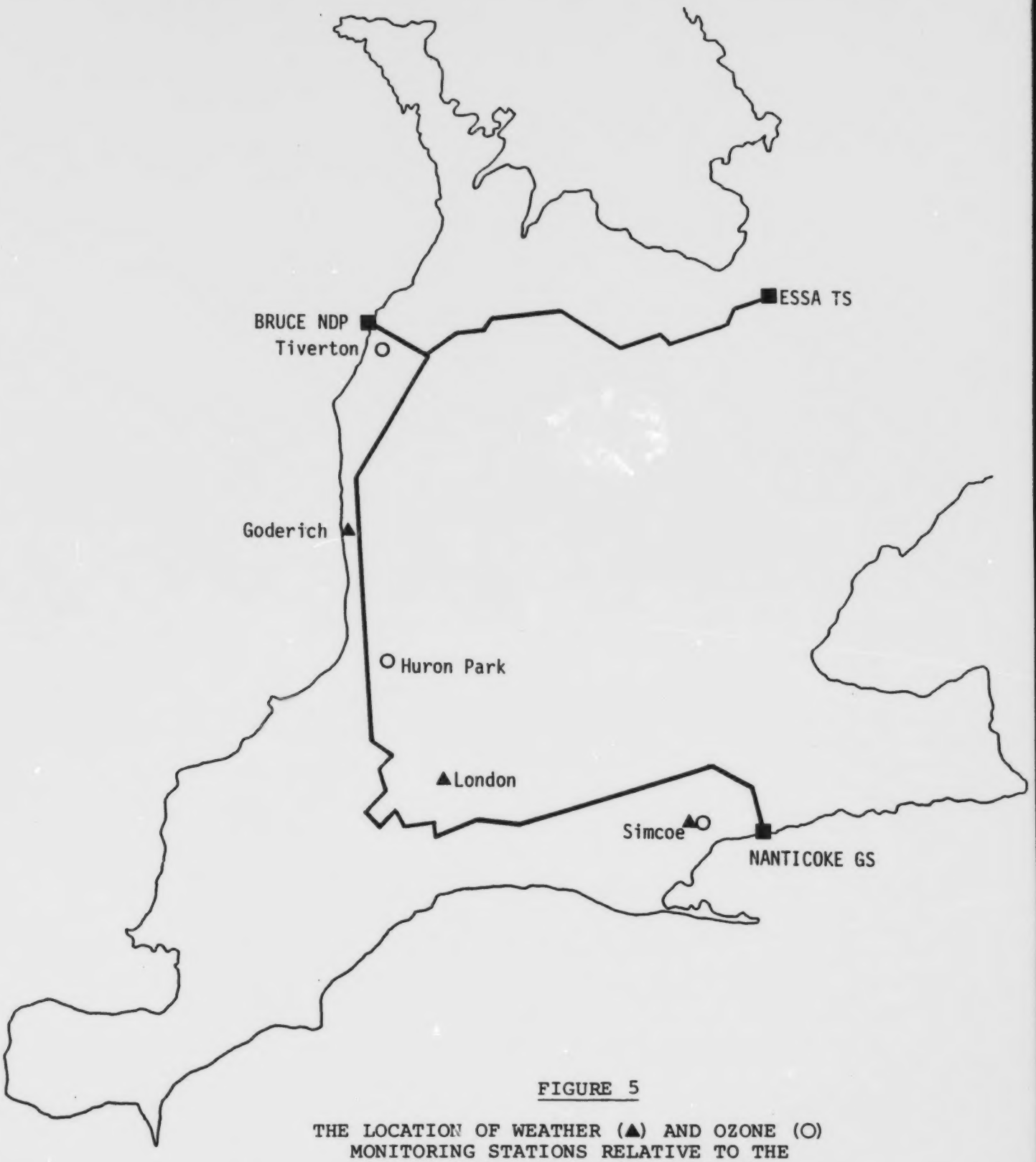

FIGURE 5

THE LOCATION OF WEATHER (▲) AND OZONE (O) MONITORING STATIONS RELATIVE TO THE TRANSMISSION FACILITIES PROPOSED FOR SOUTHWESTERN ONTARIO

Automatic weather stations suffer from a lack of some of the weather observations needed to identify fair and foul weather conditions and estimate standard deviations of particle position. Consequently, 1980 was the latest year for which the analysis could be carried out. This, and the two preceding years, 1979 and 1978, were thus used. The three years of data are expected to be representative of the long-term average weather conditions for this part of the Province. Carrying out the analysis with three years of data also provides an opportunity to assess year-to-year variability in estimated transmission line-induced ozone concentrations.

Wind speed, wind direction and precipitation and fog occurrences are measured directly. Standard deviations of particle position and mixing height, on the other hand, must be inferred from other observations. Environment Canada was asked to carry out a STAR analysis, that is, an automated classification of atmospheric stability based on cloud cover and wind speed. The PAL dispersion program has built-in equations to calculate the standard deviations of particle position once the atmospheric stability is specified. Because of the relatively low elevation of the transmission lines, and the fact that daylight, warm-season hours are involved, it was decided to set the mixing height at a fixed value of 1000 m.

RESULTS AND DISCUSSION

Sensitivity Tests

The proposed transmission lines may be considered as infinitely long line sources. Unfortunately, the PAL model is not designed to study line sources of infinite length. That is, a well defined, finite length must be specified for the line before the integration can be carried out. Furthermore, the location of the 27 receptor points allowed by the model has to be optimized so that the maximum ground-level concentration and other important features of the concentration distribution can be identified in the calculations. These aspects were studied by means of sensitivity tests.

The sensitivity tests were performed by assuming dispersion conditions thought to pose the most demanding requirements on the model. Based on the meteorological data available from London, Ontario during the study period (May 1 - September 30, 0900-1600 hours), stability Class D, with a wind speed of 6.1 m/s leads to a situation where relatively distant transmission line elements contribute to concentrations at a particular receptor. Tests were thus run for these conditions and different lengths of transmission line. For simplicity, the winds were assumed parallel to the transmission line. As expected, the concentration of ozone directly under the transmission line increased steadily with the length of the transmission line. However, as shown in Figure 6, the rate of increase became insignificant when the length of the transmission line reached

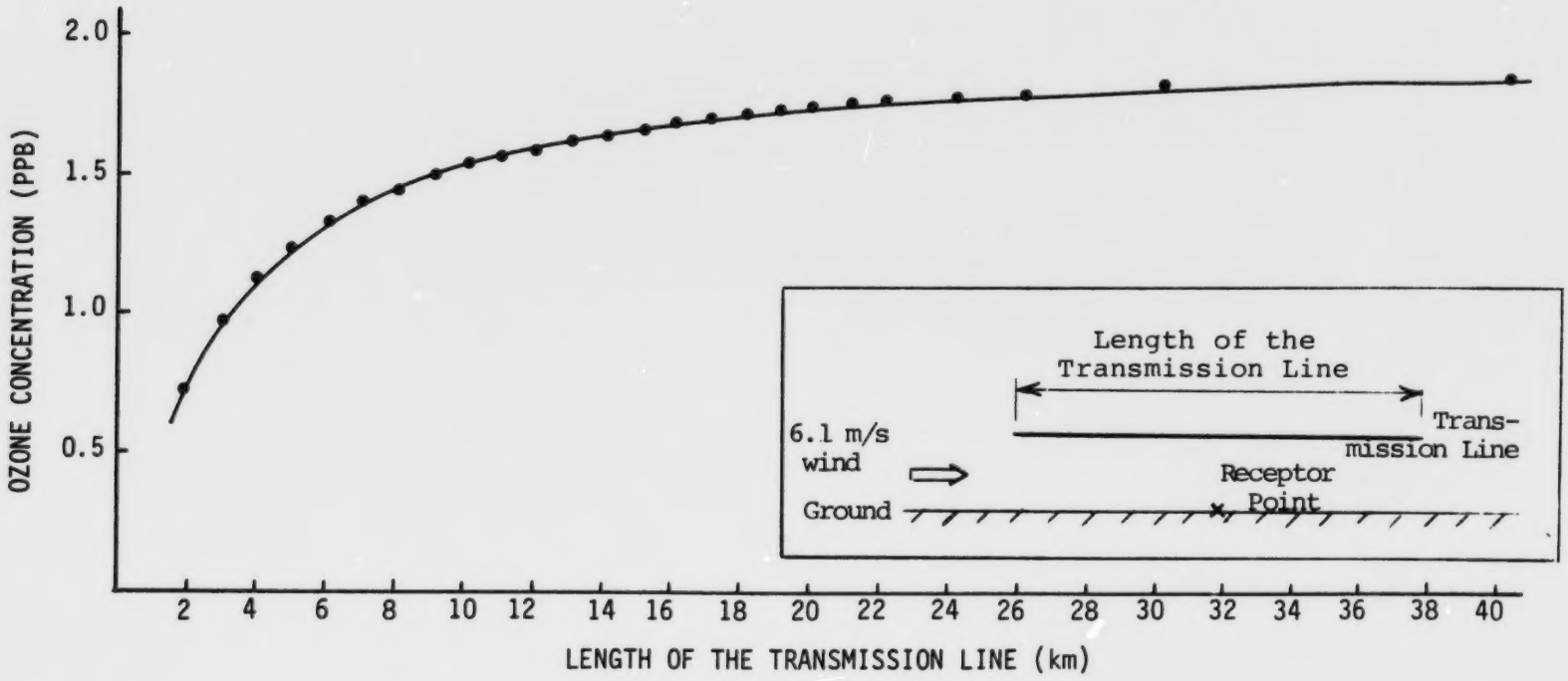

FIGURE 6

SENSITIVITY OF OZONE CONCENTRATION TO THE LENGTH OF THE TRANSMISSION LINE (THE TOTAL LENGTH OF THE LINE IS SHOWN ALONG THE ABCISSA. THE WIND OF 6.1 m/s WAS ASSUMED PARALLEL TO THE LINE AND THE RECEPTOR POINT WAS LOCATED UNDER AND AT THE MID-POINT OF THE LINE)

about 15 km (that is, 7.5 km on either side of the receptor point). Beyond that length, the concentration of ozone was nearly steady, as the contribution from additional transmission line segments was compensated by dilution of emissions from the more distant transmission line elements. Thus, a 15 km transmission line was used in the calculations.

If one ignores the first 7.5 km at either end of the transmission line, the distribution of ozone at ground level will be similar at all locations along the transmission line. That is, the ozone concentration will only vary along a line normal to the transmission line. This fact, plus the previous finding that a 15 km transmission line was sufficiently long for the calculations, formed the basis for defining the systems to be modelled and the general location of the receptor points. These were:

- o Bruce-to-London Transmission Line: a north-south transmission line, 15 km long, with a set of 27 receptor points located at the 7.5 km distance, along a line normal to the transmission line (see Figure 7), and

- o London-to-Nanticoke Transmission Line: the same as above, except that the line was 15° northeast of the west-east direction (see Figure 8).

Some additional sensitivity tests were carried out to establish the spacing of the receptor points.

Cases with winds normal and at 45° to the transmission lines were run. It was found that the maximum ground-level ozone concentration could occur anywhere within about 1.5 km to either side of the transmission line. (An example calculation (May 20, 1978) is given in Figure 9). The 27 receptor points allowed by the model were thus distributed symmetrically about the transmission line, with the spacing between points increasing away from the transmission line and covering a distance of 1.5 km in either direction (see Figures 7 and 8).

Transmission Line-Induced Ozone Concentrations

Tables AI and AII in the Appendix display the ozone concentrations calculated for the proposed Bruce-to-London and London-to-Nanticoke transmission lines using 1978, 1979 and 1980 meteorological data from Goderich, London and Simcoe. These results are shown graphically in Figures 10 to 13. More detailed plots of ozone concentration distributions are given in the Appendix (Figures A1 to A16) so that others may use the results to estimate crop yield reduction.

For the proposed Bruce-to-London line, the maximum seasonal ozone concentration is 0.0284 ppb. The overall maximum occurred with the 1978 meteorological data from Goderich and is located about 100 m to the east of the transmission line. The peak of

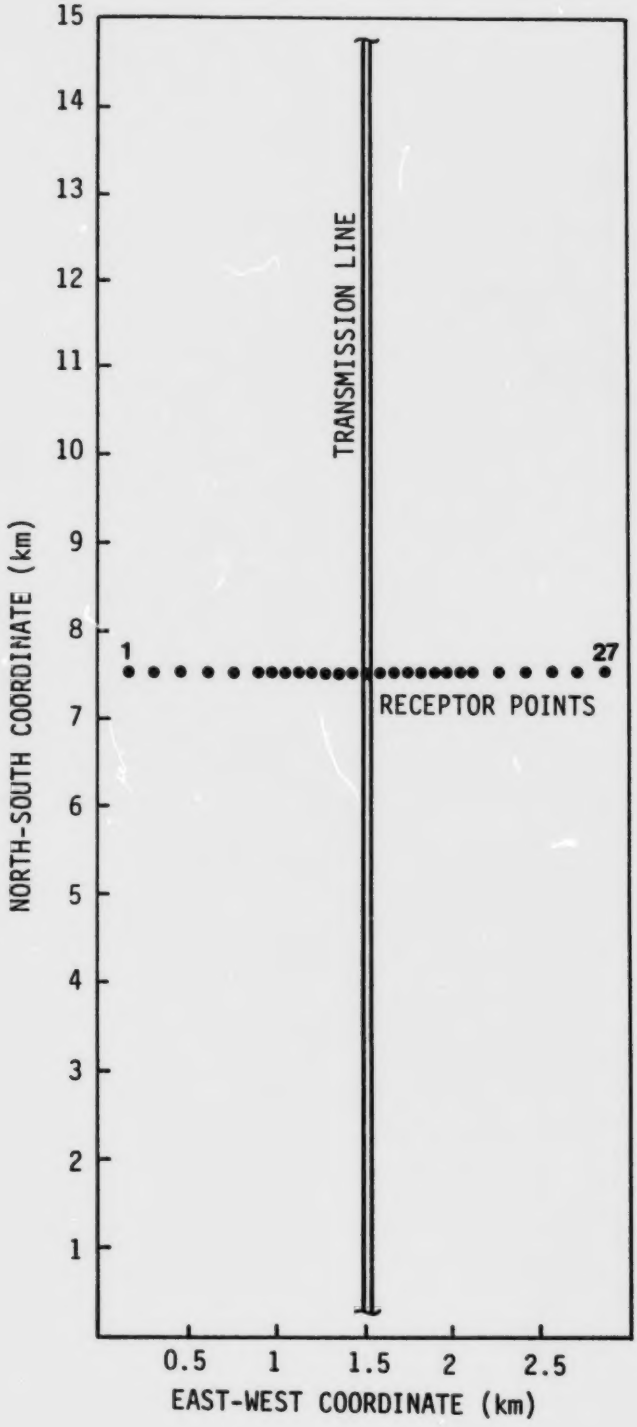

FIGURE 7

THE SYSTEM USED TO REPRESENT THE
BRUCE-TO-LONDON TRANSMISSION LINE

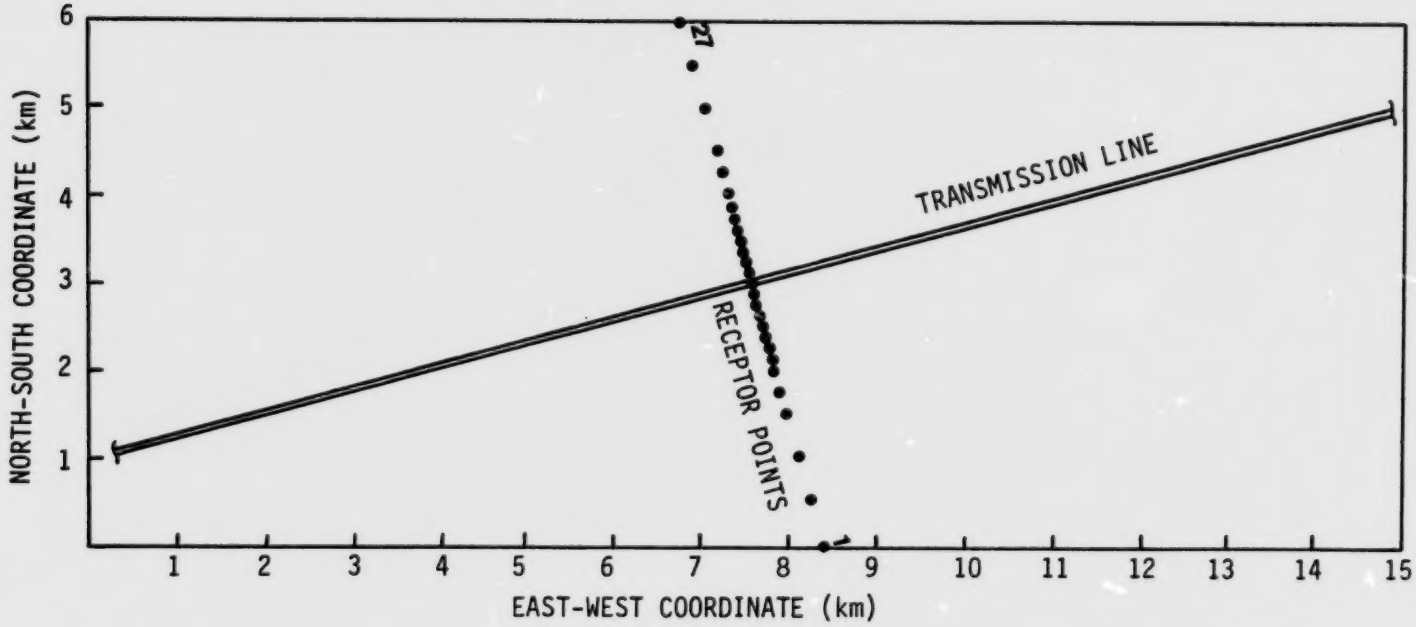

FIGURE 8

THE SYSTEM USED TO REPRESENT THE LONDON-TO-NANTICOKE TRANSMISSION LINE

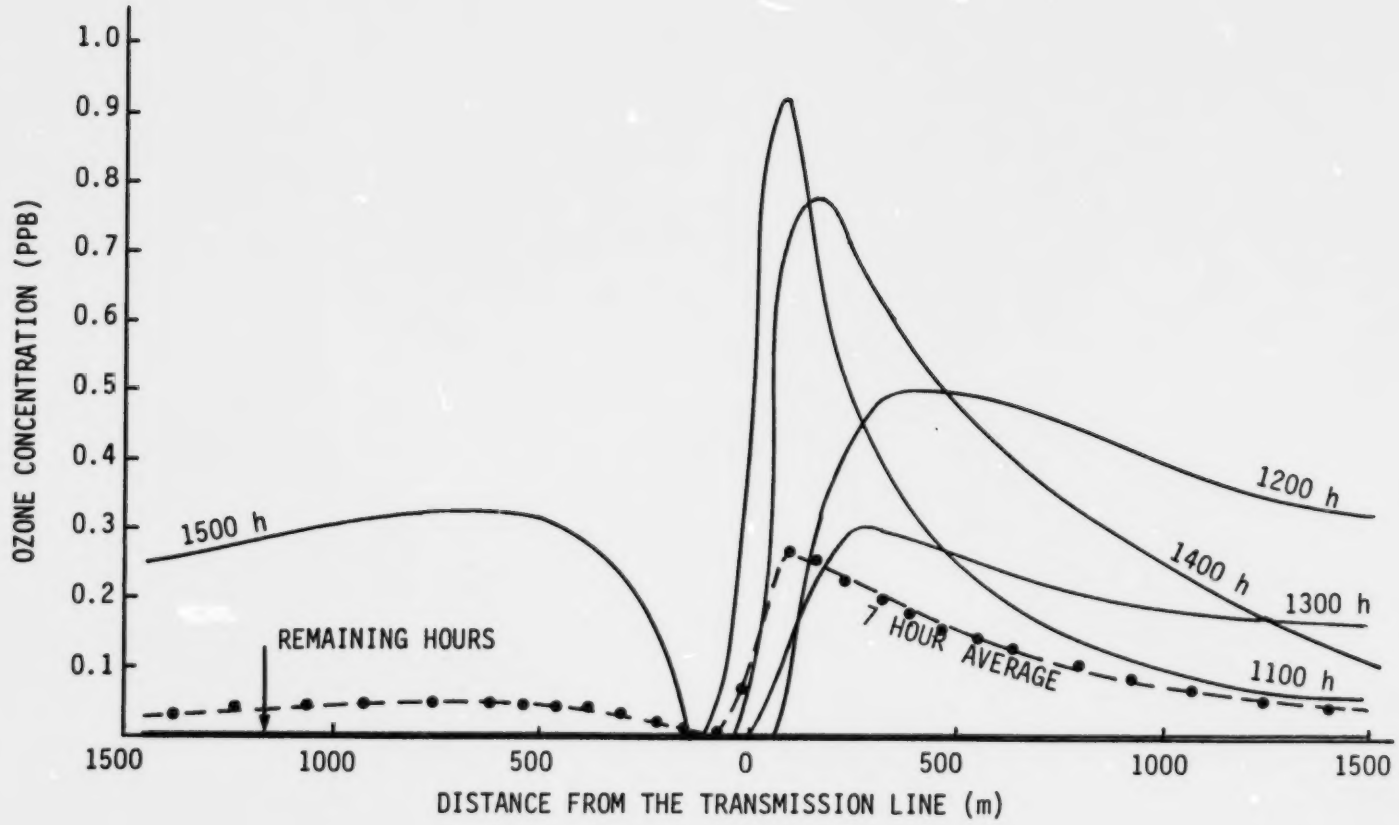

FIGURE 9

THE HOURLY AND AVERAGE OZONE CONCENTRATION FOR THE LONDON-TO-NANTICOKE TRANSMISSION LINE ON MAY 20, 1978 BASED ON LONDON WEATHER DATA

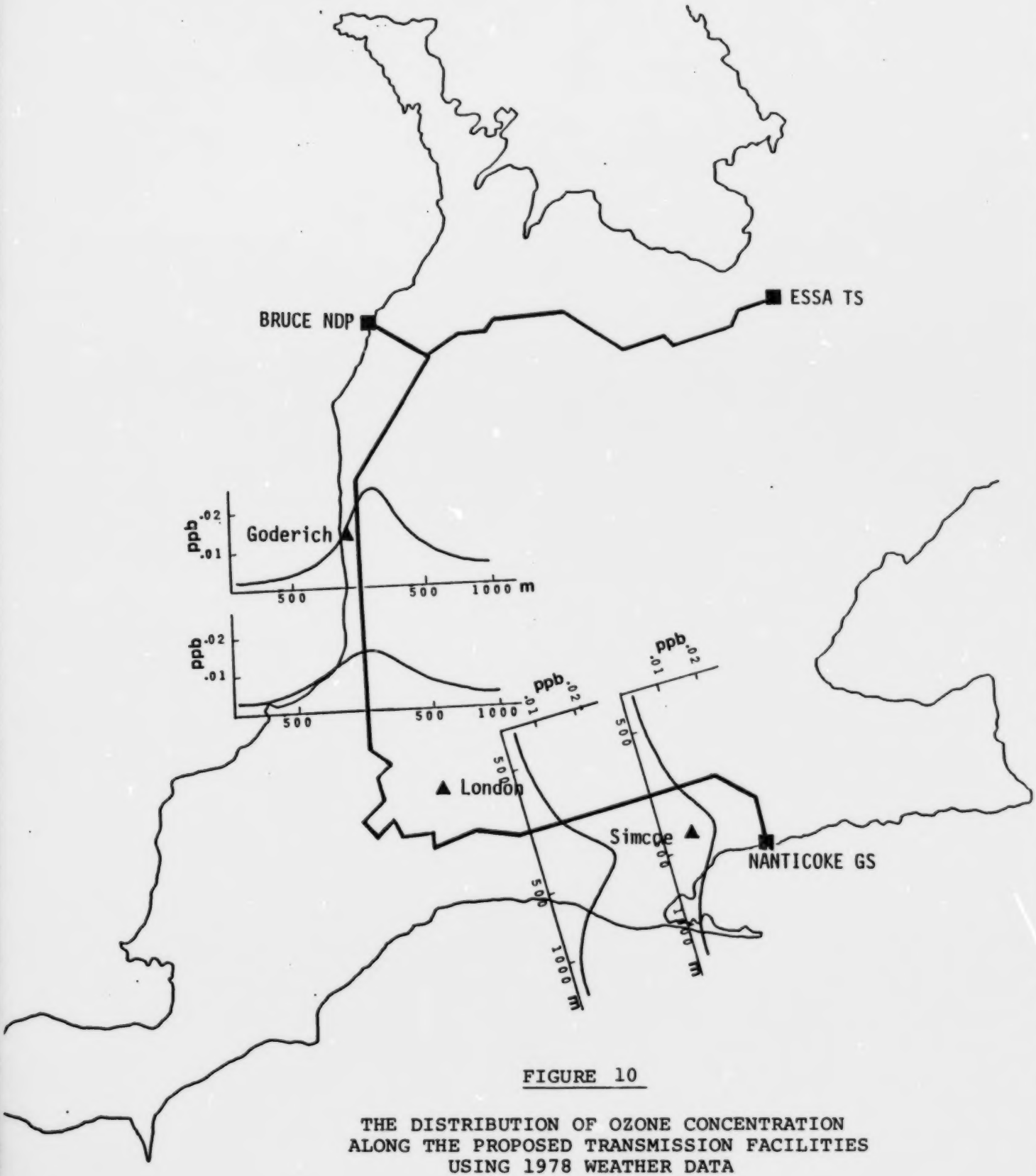

FIGURE 10

THE DISTRIBUTION OF OZONE CONCENTRATION
ALONG THE PROPOSED TRANSMISSION FACILITIES
USING 1978 WEATHER DATA

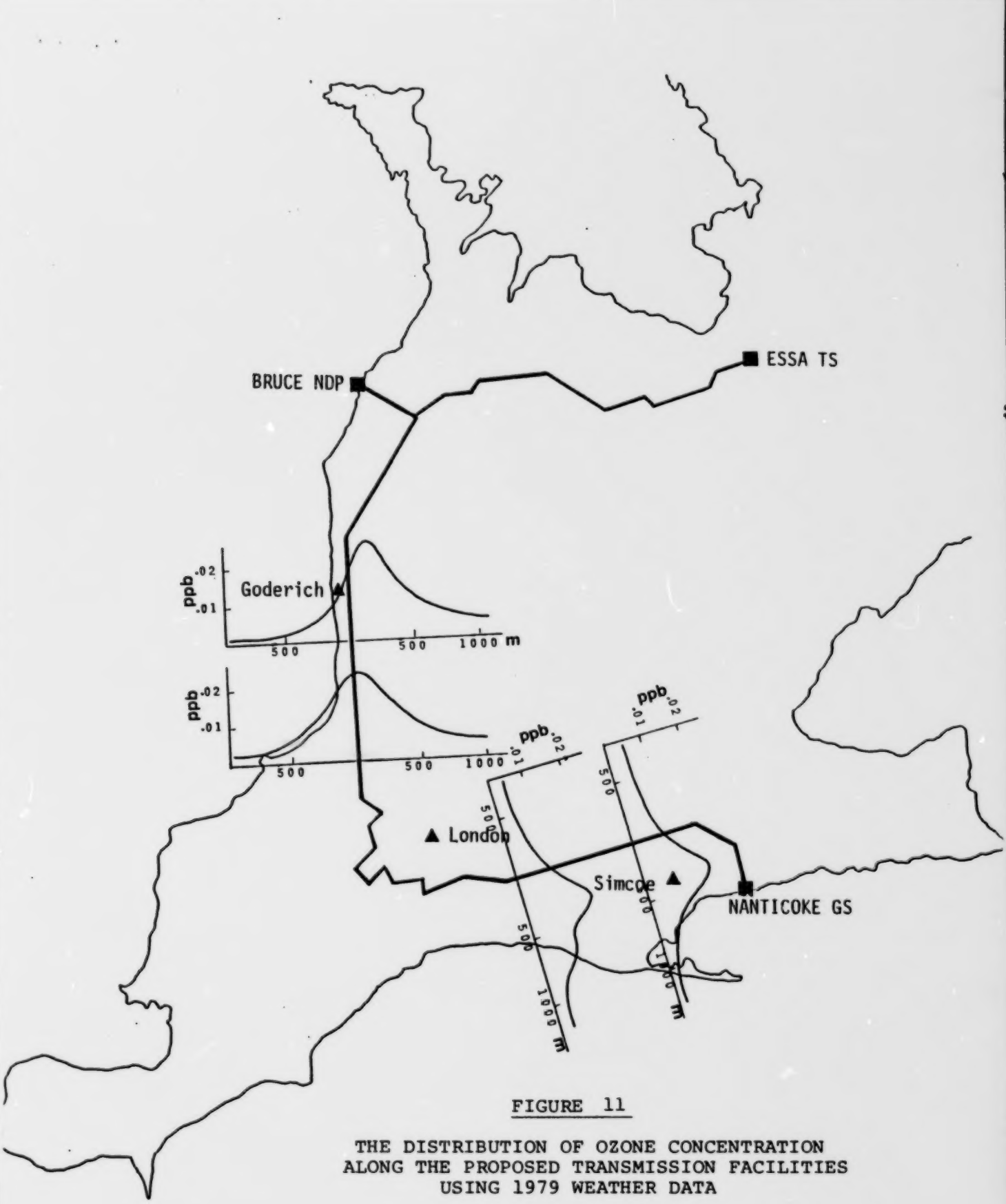

FIGURE 11

THE DISTRIBUTION OF OZONE CONCENTRATION
ALONG THE PROPOSED TRANSMISSION FACILITIES
USING 1979 WEATHER DATA

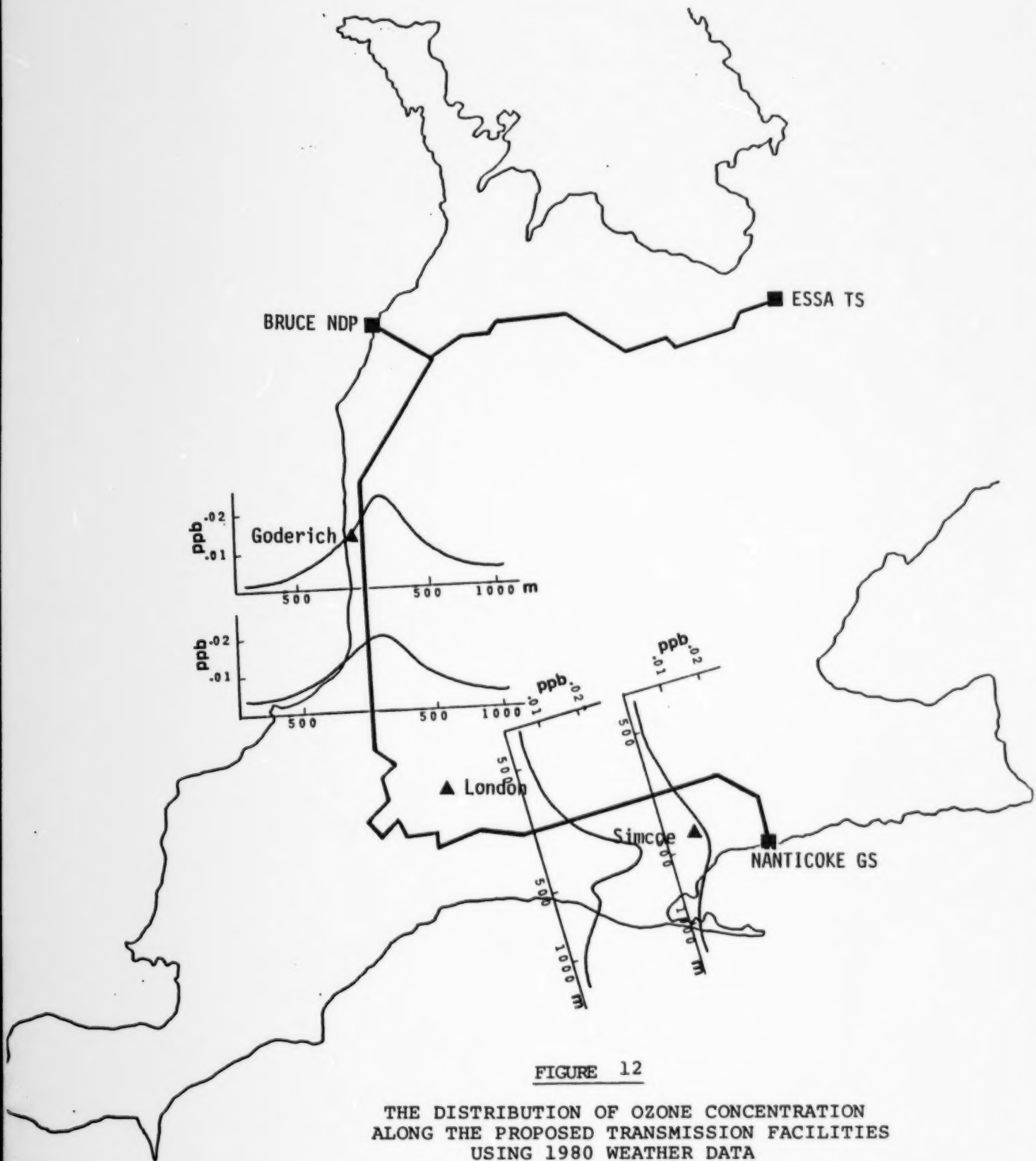

FIGURE 12

THE DISTRIBUTION OF OZONE CONCENTRATION
ALONG THE PROPOSED TRANSMISSION FACILITIES
USING 1980 WEATHER DATA

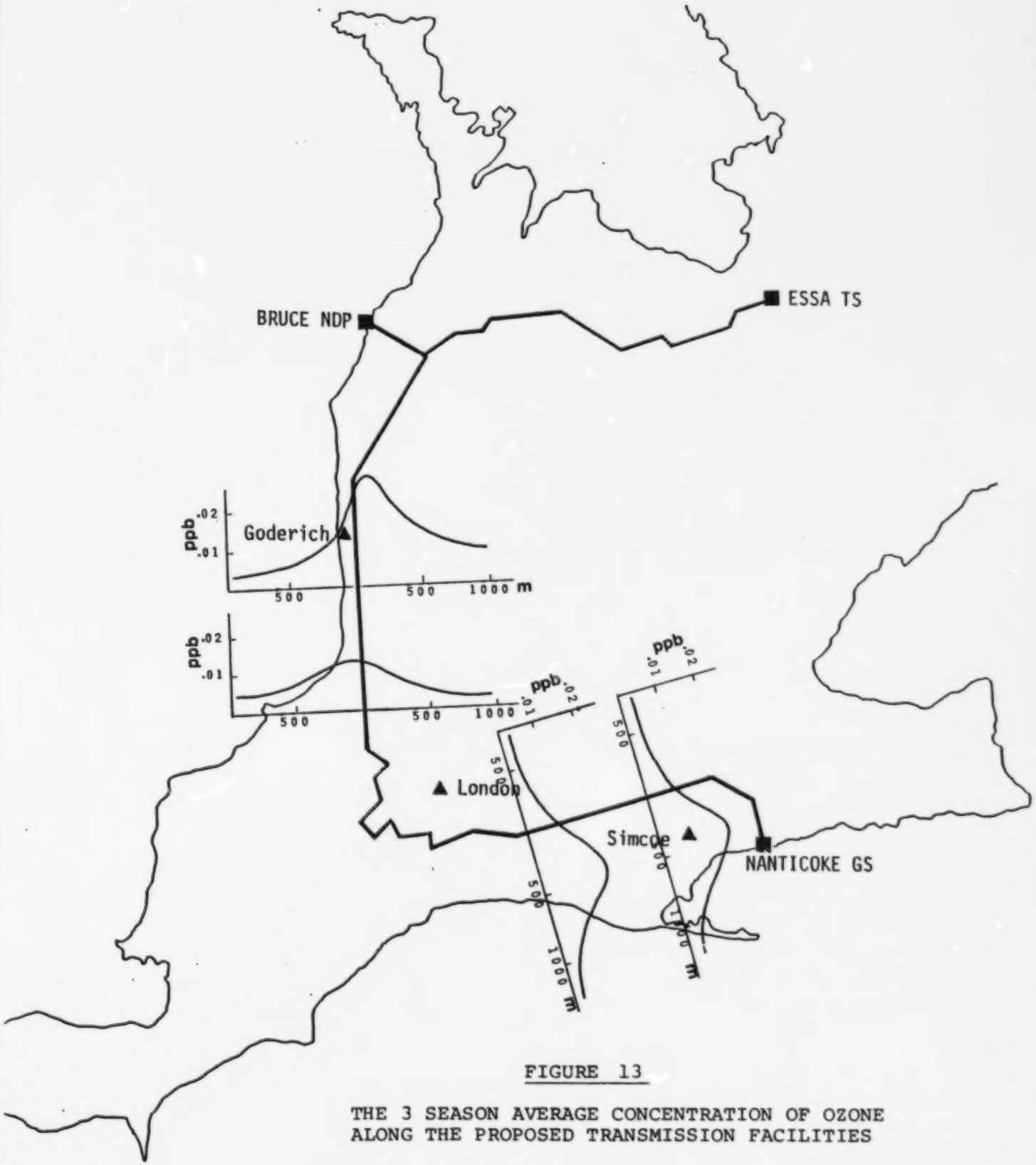

FIGURE 13

THE 3 SEASON AVERAGE CONCENTRATION OF OZONE
ALONG THE PROPOSED TRANSMISSION FACILITIES

the 3-season average concentration distribution is 0.0262 ppb, located about 150 m from the line, when meteorological data from Goderich are used. When the meteorological data from London are used, the maximum seasonal and 3-season average concentrations are 0.0242 pp (in 1979) and 0.0176 ppb, respectively. The locations of the maximum are similar to those obtained using Goderich data. The concentrations decrease gradually, falling to half about 250-450 m away from the point of maximum concentration.

In general, the ozone concentrations calculated at receptors located to the west of the line are higher when London, rather than Goderich, data are used. The reverse is true for receptors located to the east of the line. This may be attributed to differences in wind data which, in turn, determine the direction in which ozone is transported. Tables AIV to AVI in the Appendix present the frequency of occurrence of wind directions under foul- and all-weather conditions during the study period at Goderich, London and Simcoe. As can be seen from Tables AIV and AV, more easterly winds are observed at London than at Goderich. Under foul-weather conditions, the most frequent wind at Goderich is south-southwesterly with 52 hours or 16.6% of the total. On the other hand, the most frequent wind at London is southerly with 41 hours or 11.4% of the total winds.

For the proposed London-to-Nanticoke transmission line the concentrations are generally higher when London rather than Simcoe weather data are used. The maximum seasonal concentrations of ozone based on meteorological data from Simcoe and London are 0.0188 ppb (in 1979) and 0.0256 ppb (in 1980), respectively. The peaks of the 3-season average concentration distributions are 0.0153 ppb and 0.0202 ppb using Simcoe and London weather data, respectively. These peaks are located about 300 m to the south of the transmission line.

A comparison of the concentrations produced by both transmission lines, using the common meteorological data set from London, reveals that the magnitudes are generally higher for the London-to-Nanticoke transmission line than for the Bruce-to-London transmission line. This may, again, be attributed to weather conditions. As seen from Table AV, approximately 42% of the winds are easterly and westerly, compared to 34% for northerly and southerly winds. Since winds parallel to the line lead to the highest concentrations (all other factors being the same), this difference in wind direction frequency accounts for the observed differences in ozone concentration between the two transmission lines.

All of the above results have been based on the assumption that both transmission lines are of the 500 kV, double-circuit design. However, as mentioned previously, the London-to-Nanticoke transmission line is planned to have a single 500 kV circuit.

The ozone concentrations around this line will be lower than the values presented. To assess the degree of conservatism involved in our calculations, the single-circuit case was run with London weather data. The results are listed in Table AIII and plotted, along with those for the double-circuit case, in Figures A13 to A167 of the Appendix. The ozone concentrations, due to the single-circuit line, are only slightly larger than half the concentrations due to the double-circuit line. The former is not exactly half of the latter because the conductor geometry is different. (See Figure 2)

Ambient Ozone Concentrations

The Ontario Ministry of the Environment monitors ozone concentrations at several locations in the Province. Data from three monitoring stations in Southwestern Ontario (Tiverton, Huron Park and Simcoe - see Figure 5), are summarized in Tables AVII to AIX of the Appendix. Concentrations are highest in Simcoe and decrease towards the north, no doubt reflecting the fact that long-range transport and urban emissions are important sources of ozone in Southwestern Ontario. Seasonal averages are in the range of 31 to 54 ppb, with year-to-year variability as high as 8 ppb.

CONCLUSIONS

The 500 kV, single- and double-circuit transmission lines proposed for Southwestern Ontario are expected to generate small amounts of ozone, particularly during bad weather conditions when corona activity is at its peak. Extensive measurements of corona discharge rates, made by Ontario Hydro in the 1950's and early 60's, and of ozone production efficiency measurements described in the literature were used to estimate that the source strength of the double-circuit transmission line proposed for Southwestern Ontario will be about 0.8 and 72 $\mu g/m.s$ during fair- and foul-weather conditions, respectively. These values should be halved for the single-circuit transmission line.

The transmission line-induced ozone will be carried away from the vicinity of the conductors and dispersed by the wind. When the steady-state, Gaussian dispersion model PAL was applied to the Southwestern Ontario transmission lines, it was found that the ozone concentrations are expected to be less than 0.03 parts per billion at the ground near the transmission line, gradually falling to zero away from the transmission line (the concentrations are reduced in half by 250-450 m). The 0.03 ppb peak value is less than 0.1% of the ozone concentrations which now occur in this part of the Province.

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APPENDIX

TABLE AI

YEARLY AND TOTAL AVERAGE OF OZONE CONCENTRATION (PPB)
ALONG THE PROPOSED BRUCE-LONDON LINE USING
1978-1980 GODERICH WEATHER DATA

RECEPTOR NO	1978 AVERAGE	1979 AVERAGE	1980 AVERAGE	TOTAL AVERAGE
1	0.0032100	0.0012300	0.0011800	0.0018733
2	0.0035000	0.0013700	0.0013200	0.0020633
3	0.0038500	0.0015400	0.0015200	0.0023033
4	0.0042900	0.0017700	0.0018200	0.0026267
5	0.0048500	0.0021200	0.0022800	0.0030833
6	0.0056400	0.0026700	0.0030600	0.0037900
7	0.0061600	0.0030800	0.0036700	0.0043033
8	0.0068300	0.0036200	0.0045000	0.0049833
9	0.0076900	0.0043200	0.0056100	0.0058733
10	0.0088200	0.0053300	0.0070900	0.0070800
11	0.0103000	0.0067700	0.0090000	0.0086900
12	0.0125000	0.0089900	0.0111000	0.0108633
13	0.0161000	0.0128000	0.0118000	0.0135667
14	0.0248000	0.0196000	0.0141000	0.0195000
15	0.0284000	0.0251000	0.0225000	0.0253333
16	0.0269000	0.0273000	0.0245000	0.0262333
17	0.0235000	0.0236000	0.0208000	0.0226333
18	0.0204000	0.0194000	0.0167000	0.0188333
19	0.0177000	0.0160000	0.0134000	0.0157000
20	0.0157000	0.0133000	0.0109000	0.0133000
21	0.0141000	0.0112000	0.0089500	0.0114167
22	0.0128000	0.0095800	0.0075500	0.0099767
23	0.0108000	0.0074500	0.0057500	0.0080000
24	0.0094700	0.0061400	0.0047200	0.0067767
25	0.0084400	0.0053000	0.0040800	0.0059400
26	0.0076100	0.0047000	0.0036500	0.0053200
27	0.0069300	0.0042500	0.0033300	0.0048367

YEARLY AND TOTAL AVERAGE OF OZONE CONCENTRATION (PPB)
ALONG THE PROPOSED BRUCE-LONDON LINE USING
1978-1980 LONDON WEATHER DATA

RECEPTOR NO	1978 AVERAGE	1979 AVERAGE	1980 AVERAGE	TOTAL AVERAGE
1	0.0036300	0.0020300	0.0025400	0.0027333
2	0.0039500	0.0022600	0.0028400	0.0030167
3	0.0043400	0.0025400	0.0032400	0.0033733
4	0.0048300	0.0029200	0.0037900	0.0038467
5	0.0054500	0.0034900	0.0045600	0.0045000
6	0.0063100	0.0044300	0.0057500	0.0054967
7	0.0069000	0.0051600	0.0066000	0.0062200
8	0.0075600	0.0061700	0.0077000	0.0071433
9	0.0084000	0.0075900	0.0091100	0.0083667
10	0.0093800	0.0096500	0.0109000	0.0099767
11	0.0105000	0.0126000	0.0131000	0.0120667
12	0.0118000	0.0169000	0.0153000	0.0146667
13	0.0130000	0.0214000	0.0160000	0.0168000
14	0.0121000	0.0220000	0.0174000	0.0171667
15	0.0092900	0.0242000	0.0189000	0.0174633
16	0.0094600	0.0233000	0.0201000	0.0176200
17	0.0085500	0.0197000	0.0179000	0.0153833
18	0.0073700	0.0163000	0.0152000	0.0129567
19	0.0063000	0.0136000	0.0128000	0.0109000
20	0.0054000	0.0115000	0.0109000	0.0092667
21	0.0046800	0.0098500	0.0093200	0.0079500
22	0.0041100	0.0086100	0.0081500	0.0069567
23	0.0033000	0.0069100	0.0065000	0.0055700
24	0.0027400	0.0058100	0.0054100	0.0046533
25	0.0023500	0.0050300	0.0046500	0.0040100
26	0.0020500	0.0044400	0.0040900	0.0035267
27	0.0018300	0.0039800	0.0036800	0.0031633

TABLE AII

YEARLY AND TOTAL AVERAGE OF OZONE CONCENTRATION (PPB)
ALONG THE PROPOSED NANTICOKE-LONDON LINE USING
1978-1980 SIMCOE WEATHER DATA

RECEPTOR NO	1978 AVERAGE	1979 AVERAGE	1980 AVERAGE	TOTAL AVERAGE
1	0.0013400	0.0012400	0.0008120	0.0011307
2	0.0015900	0.0014800	0.0010500	0.0013733
3	0.0019800	0.0017800	0.0014000	0.0017200
4	0.0027400	0.0022900	0.0020200	0.0023500
5	0.0035300	0.0027400	0.0025900	0.0029533
6	0.0052700	0.0036500	0.0036200	0.0041800
7	0.0070100	0.0044800	0.0045100	0.0053333
8	0.0098800	0.0057400	0.0058900	0.0071700
9	0.0140000	0.0076000	0.0082000	0.0099333
10	0.0146000	0.0092000	0.0123000	0.0120333
11	0.0187000	0.0171000	0.0101000	0.0153000
12	0.0159000	0.0188000	0.0101000	0.0149333
13	0.0103000	0.0142000	0.0081100	0.0108700
14	0.0080300	0.0112000	0.0066800	0.0086367
15	0.0065400	0.0091100	0.0056000	0.0070833
16	0.0055400	0.0077200	0.0048100	0.0060233
17	0.0048200	0.0067200	0.0042100	0.0052500
18	0.0042700	0.0059900	0.0037400	0.0046667
19	0.0038500	0.0054300	0.0033700	0.0042167
20	0.0035100	0.0050000	0.0030600	0.0038567
21	0.0032300	0.0046400	0.0028100	0.0035600
22	0.0029900	0.0043500	0.0026000	0.0033133
23	0.0026100	0.0038700	0.0022500	0.0029100
24	0.0023000	0.0035000	0.0019900	0.0025967
25	0.0018500	0.0029700	0.0016400	0.0021533
26	0.0015100	0.0026000	0.0013900	0.0018333
27	0.0012500	0.0023200	0.0011900	0.0015867

YEARLY AND TOTAL AVERAGE OF OZONE CONCENTRATION (PPB)
ALONG THE PROPOSED NANTICOKE-LONDON LINE USING
1978-1980 LONDON WEATHER DATA

RECEPTOR NO	1978 AVERAGE	1979 AVERAGE	1980 AVERAGE	TOTAL AVERAGE
1	0.0007820	0.0014000	0.0012400	0.0011407
2	0.0009320	0.0016600	0.0014700	0.0013540
3	0.0012000	0.0020600	0.0018200	0.0016933
4	0.0017900	0.0027500	0.0025500	0.0023633
5	0.0024700	0.0033600	0.0033600	0.0030633
6	0.0039900	0.0046200	0.0050900	0.0045667
7	0.0055300	0.0058500	0.0067600	0.0060467
8	0.0080600	0.0078900	0.0093600	0.0084367
9	0.0122000	0.0111000	0.0125000	0.0119333
10	0.0171000	0.0109000	0.0109000	0.0129667
11	0.0183000	0.0168000	0.0256000	0.0202333
12	0.0164000	0.0186000	0.0230000	0.0193333
13	0.0113000	0.0137000	0.0149000	0.0133000
14	0.0087600	0.0105000	0.0112000	0.0101533
15	0.0071100	0.0082500	0.0089200	0.0080933
16	0.0059900	0.0068300	0.0074100	0.0067433
17	0.0052000	0.0058500	0.0063600	0.0058033
18	0.0046200	0.0051500	0.0055800	0.0051167
19	0.0041600	0.0046300	0.0050000	0.0045967
20	0.0038000	0.0042200	0.0045400	0.0041867
21	0.0035100	0.0039000	0.0041600	0.0038567
22	0.0032600	0.0036300	0.0038400	0.0035767
23	0.0028600	0.0031900	0.0033200	0.0031233
24	0.0025500	0.0028600	0.0029300	0.0027800
25	0.0020600	0.0023900	0.0023500	0.0022667
26	0.0016600	0.0020700	0.0019400	0.0018900
27	0.0013800	0.0018400	0.0016500	0.0016233

TABLE AIII

YEARLY AND TOTAL AVERAGE OF OZONE CONCENTRATION (PPB)
ALONG THE PROPOSED NANTICOKE-LONDON LINE USING
1978-1980 LONDON WEATHER DATA
(FOR A 500 KV SINGLE CIRCUIT CASE)

RECEPTOR NO	1978 AVERAGE	1979 AVERAGE	1980 AVERAGE	TOTAL AVERAGE
1	0.0003920	0.0007080	0.0006250	0.0005750
2	0.0004690	0.0008440	0.0007410	0.0006847
3	0.0006020	0.0010600	0.0009220	0.0008613
4	0.0009050	0.0014200	0.0013000	0.0012083
5	0.0012500	0.0017700	0.0017300	0.0015833
6	0.0020500	0.0024800	0.0026600	0.0023967
7	0.0028700	0.0031800	0.0036000	0.0032167
8	0.0043000	0.0043800	0.0051600	0.0046133
9	0.0070200	0.0065900	0.0076400	0.0070833
10	0.0105000	0.0070100	0.0068000	0.0081033
11	0.0114000	0.0117000	0.0164000	0.0131667
12	0.0096600	0.0116000	0.0135000	0.0115867
13	0.0061800	0.0074800	0.0080100	0.0072233
14	0.0047100	0.0055400	0.0058900	0.0053800
15	0.0037700	0.0043200	0.0046200	0.0042367
16	0.0031500	0.0035300	0.0038100	0.0034967
17	0.0027100	0.0030000	0.0032600	0.0029900
18	0.0024000	0.0026300	0.0028500	0.0026267
19	0.0021600	0.0023600	0.0025400	0.0023533
20	0.0019600	0.0021400	0.0023000	0.0021333
21	0.0018000	0.0019700	0.0021000	0.0019567
22	0.0016700	0.0018400	0.0019400	0.0018167
23	0.0014600	0.0016100	0.0016800	0.0015833
24	0.0013000	0.0014400	0.0014800	0.0014067
25	0.0010500	0.0012000	0.0011800	0.0011433
26	0.0008400	0.0010400	0.0009770	0.0009523
27	0.0007000	0.0009250	0.0008280	0.0008177

TABLE AIV

FREQUENCY OF OCCURRENCE OF WIND DIRECTIONS UNDER FOUL WEATHER CONDITIONS AT GODERICH BETWEEN 1978 AND 1980

WIND DIRECTION	HOUR 1978	HOUR 1979	HOUR 1980	TOTAL HOUR	PERCENTAGE OF OCCURRENCE
N	8	13	12	33	10.5
NNE	0	2	2	4	1.3
NE	1	1	1	3	1.0
ENE	1	1	0	2	0.6
E	9	2	3	14	4.5
ESE	8	1	5	14	4.5
SE	14	1	7	22	7.0
SSE	5	4	2	11	3.5
S	18	1	3	22	7.0
SSW	22	24	6	52	16.6
SW	9	4	11	24	7.7
WSW	4	9	10	23	7.3
W	3	8	10	21	6.7
WNW	1	8	5	14	4.5
NW	6	7	8	21	6.7
NNW	11	11	11	33	10.5

FREQUENCY OF OCCURRENCE OF WIND DIRECTIONS UNDER ALL WEATHER CONDITIONS AT GODERICH BETWEEN 1978 AND 1980

WIND DIRECTION	HOUR 1978	HOUR 1979	HOUR 1980	TOTAL HOUR	PERCENTAGE OF OCCURRENCE
N	31	73	46	150	4.7
NNE	11	25	19	55	1.7
NE	6	27	10	43	1.4
ENE	19	8	6	33	1.0
E	46	16	14	76	2.4
ESE	34	23	28	85	2.7
SE	43	25	31	99	3.1
SSE	29	28	37	94	3.0
S	89	47	66	202	6.4
SSW	190	230	184	604	19.0
SW	117	91	143	351	11.0
WSW	87	67	88	242	7.6
W	63	82	76	221	6.9
WNW	44	58	50	152	4.8
NW	91	96	88	275	8.6
NNW	171	157	171	499	15.7

TABLE AV

FREQUENCY OF OCCURRENCE OF WIND DIRECTIONS UNDER FOUL WEATHER CONDITIONS AT LONDON BETWEEN 1978 AND 1980

WIND DIRECTION	HOUR 1978	HOUR 1979	HOUR 1980	TOTAL HOUR	PERCENTAGE OF OCCURRENCE
N	4	8	5	17	4.7
NNE	1	1	1	3	0.8
NE	0	0	1	1	0.3
ENE	8	4	2	14	3.9
E	24	0	13	37	10.3
ESE	8	2	10	20	5.6
SE	10	13	9	32	8.9
SSE	9	8	16	33	9.2
S	10	18	13	41	11.4
SSW	1	20	4	25	6.9
SW	4	10	18	32	8.9
WSW	8	9	15	32	8.9
W	4	8	6	18	5.0
WNW	7	8	14	29	8.1
NW	6	8	8	22	6.1
NNW	0	3	1	4	1.1

FREQUENCY OF OCCURRENCE OF WIND DIRECTIONS UNDER ALL WEATHER CONDITIONS AT LONDON BETWEEN 1978 AND 1980

WIND DIRECTION	HOUR 1978	HOUR 1979	HOUR 1980	TOTAL HOUR	PERCENTAGE OF OCCURRENCE
N	74	53	71	198	6.2
NNE	20	20	15	55	1.7
NE	11	18	24	53	1.6
ENE	35	29	13	77	2.4
E	80	63	57	200	6.2
ESE	40	33	41	114	3.5
SE	40	51	46	137	4.3
SSE	50	97	55	202	6.3
S	122	149	112	383	11.9
SSW	98	93	82	273	8.5
SW	60	71	62	193	6.0
WSW	73	63	83	219	6.8
W	94	92	118	304	9.5
WNW	103	102	142	347	10.8
NW	101	90	88	279	8.7
NNW	70	47	62	179	5.6

TABLE AVI

FREQUENCY OF OCCURRENCE OF WIND DIRECTIONS UNDER FOUL WEATHER CONDITIONS AT SIMCOE BETWEEN 1978 AND 1980

WIND DIRECTION	HOUR 1978	HOUR 1979	HOUR 1980	TOTAL HOUR	PERCENTAGE OF OCCURRENCE
N	7	1	1	9	3.1
NNE	6	6	1	13	4.5
NE	18	4	4	26	9.0
ENE	4	3	4	11	3.8
E	17	2	3	22	7.6
ESE	13	4	1	18	6.2
SE	4	9	8	21	7.2
SSE	3	11	5	19	6.6
S	7	18	7	32	11.0
SSW	3	23	5	31	10.7
SW	8	14	10	32	11.0
WSW	8	5	4	17	5.9
W	4	4	9	17	5.9
WNW	0	5	5	10	3.4
NW	1	4	1	6	2.1
NNW	0	3	3	6	2.1

FREQUENCY OF OCCURRENCE OF WIND DIRECTIONS UNDER ALL WEATHER CONDITIONS AT SIMCOE BETWEEN 1978 AND 1980

WIND DIRECTION	HOUR 1978	HOUR 1979	HOUR 1980	TOTAL HOUR	PERCENTAGE OF OCCURRENCE
N	52	30	19	101	3.3
NNE	40	40	20	100	3.3
NE	62	42	31	135	4.4
ENE	34	36	29	99	3.2
E	43	46	29	118	3.8
ESE	45	32	28	105	3.4
SE	45	65	42	152	4.9
SSE	93	108	68	269	8.7
S	91	122	89	302	9.8
SSW	108	106	102	316	10.3
SW	107	110	97	314	10.2
WSW	76	77	71	224	7.3
W	77	78	110	265	8.6
WNW	71	75	93	239	7.8
NW	81	55	66	202	6.6
NNW	46	49	39	134	4.4

TABLE AVII

AMBIENT OZONE CONCENTRATIONS (PPB) IN 1978
MEASURED BY ONTARIO MINISTRY OF THE ENVIRONMENT

Simcoe

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	Average
May	58	62	65	67	67	67	68	65
Jun	43	47	51	55	57	58	60	53
Jul	43	51	56	60	63	65	66	58
Aug	43	49	55	60	63	66	66	57
Sept	27	32	37	40	42	44	45	38
Average	43	48	53	56	58	60	61	54

Huron Park

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	Average
May	34	39	40	43	43	44	42	41
Jun	31	35	38	39	42	43	46	39
Jul	35	39	43	45	47	48	49	44
Aug	38	45	49	53	57	60	60	52
Sept	25	30	34	38	40	40	41	35
Average	33	38	41	44	46	47	48	42

Tiverton

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	Average
May	Station did not operate in 1978							
Jun								
Jul								
Aug								
Sept								

TABLE AVIII

AMBIENT OZONE CONCENTRATIONS (PPB) IN 1979 MEASURED BY ONTARIO MINISTRY OF THE ENVIRONMENT

Simcoe

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	Average
May	34	38	41	43	45	45	45	42
Jun	40	46	50	54	57	60	60	52
Jul	40	45	50	53	54	53	57	50
Aug	30	35	38	42	45	49	49	41
Sept	29	34	40	44	47	49	50	42
Average	35	40	44	47	50	51	52	46

Huron Park

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	Average
May	22	24	27	30	31	32	33	28
Jun	29	33	37	40	42	44	45	39
Jul	35	39	43	45	44	46	48	43
Aug	31	38	45	51	51	51	51	45
Sept	30	36	40	44	47	48	48	42
Average	29	34	38	42	43	44	45	39

Tiverton

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	Average
May	34	36	39	43	45	45	45	41
Jun	34	36	41	43	45	46	44	41
Jul	28	31	32	35	36	35	32	33
Aug	26	28	29	34	35	35	32	31
Sept	29	30	33	36	38	40	36	35
Average	30	32	35	38	40	40	38	36

TABLE AIX

AMBIENT OZONE CONCENTRATIONS (PPB) IN 1980 MEASURED BY ONTARIO MINISTRY OF THE ENVIRONMENT

Simcoe

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	Average
May	34	38	41	44	47	45	45	42
Jun	33	39	43	46	47	48	49	44
Jul	36	41	43	46	48	49	49	46
Aug	33	38	42	46	49	50	51	44
Sept	25	30	34	36	39	41	41	35
Average	32	37	41	44	46	47	47	42

Huron Park

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	Average
May	32	38	41	41	44	46	46	41
Jun	32	36	40	44	45	46	46	41
Jul	29	34	37	40	41	42	45	38
Aug	25	30	33	37	39	42	43	36
Sept	20	24	27	30	32	33	33	28
Average	28	32	36	38	40	42	43	37

Tiverton

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	Average
May	31	31	34	34	33	35	30	33
Jun	21	23	23	26	30	30	33	27
Jul	30	32	33	35	35	36	32	33
Aug	29	30	33	38	42	42	39	36
Sept	23	24	25	27	29	28	26	26
Average	27	28	30	32	34	34	32	31

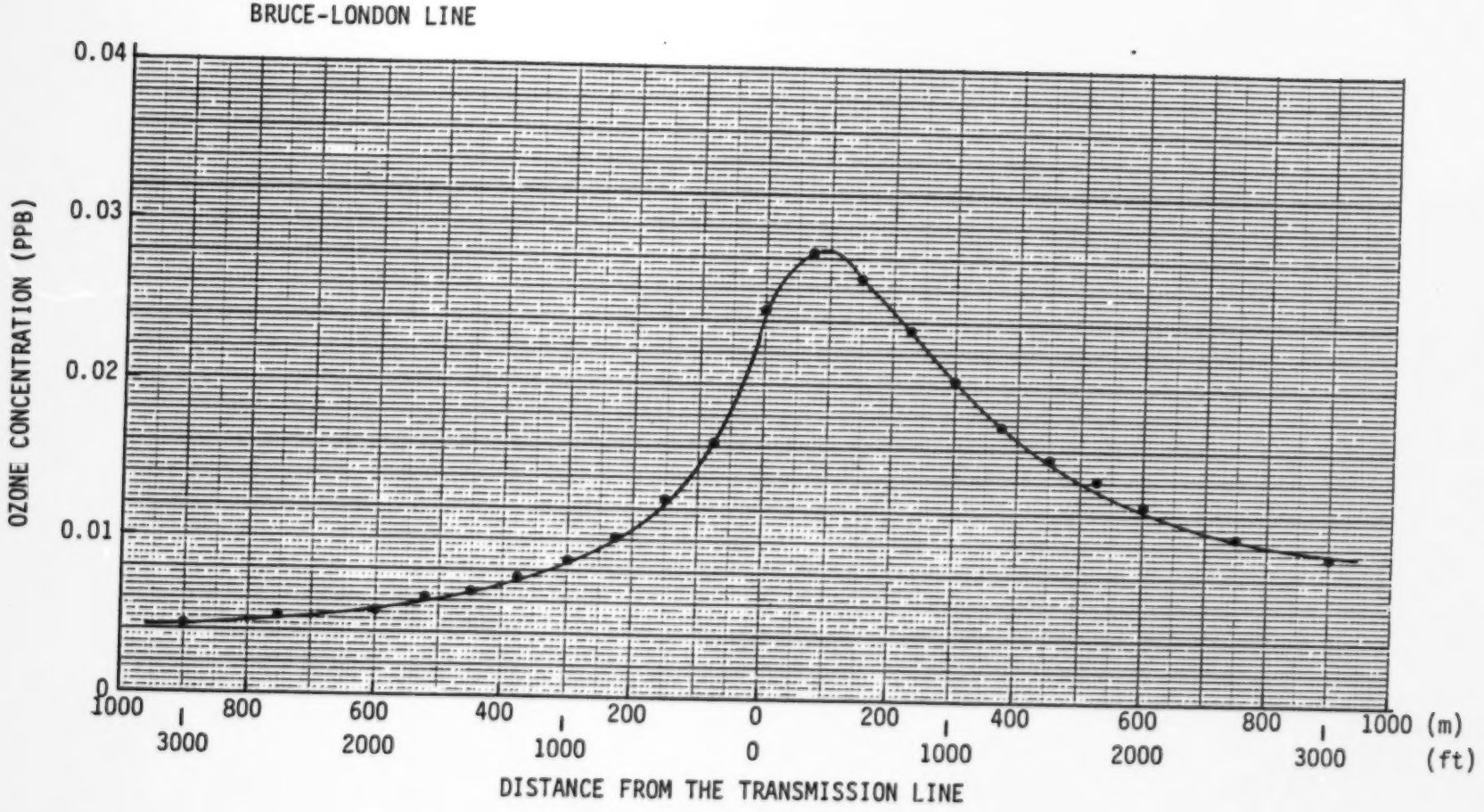

FIGURE A1

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED BRUCE-TO-LONDON TRANSMISSION LINE USING 1978 GODERICH WEATHER DATA

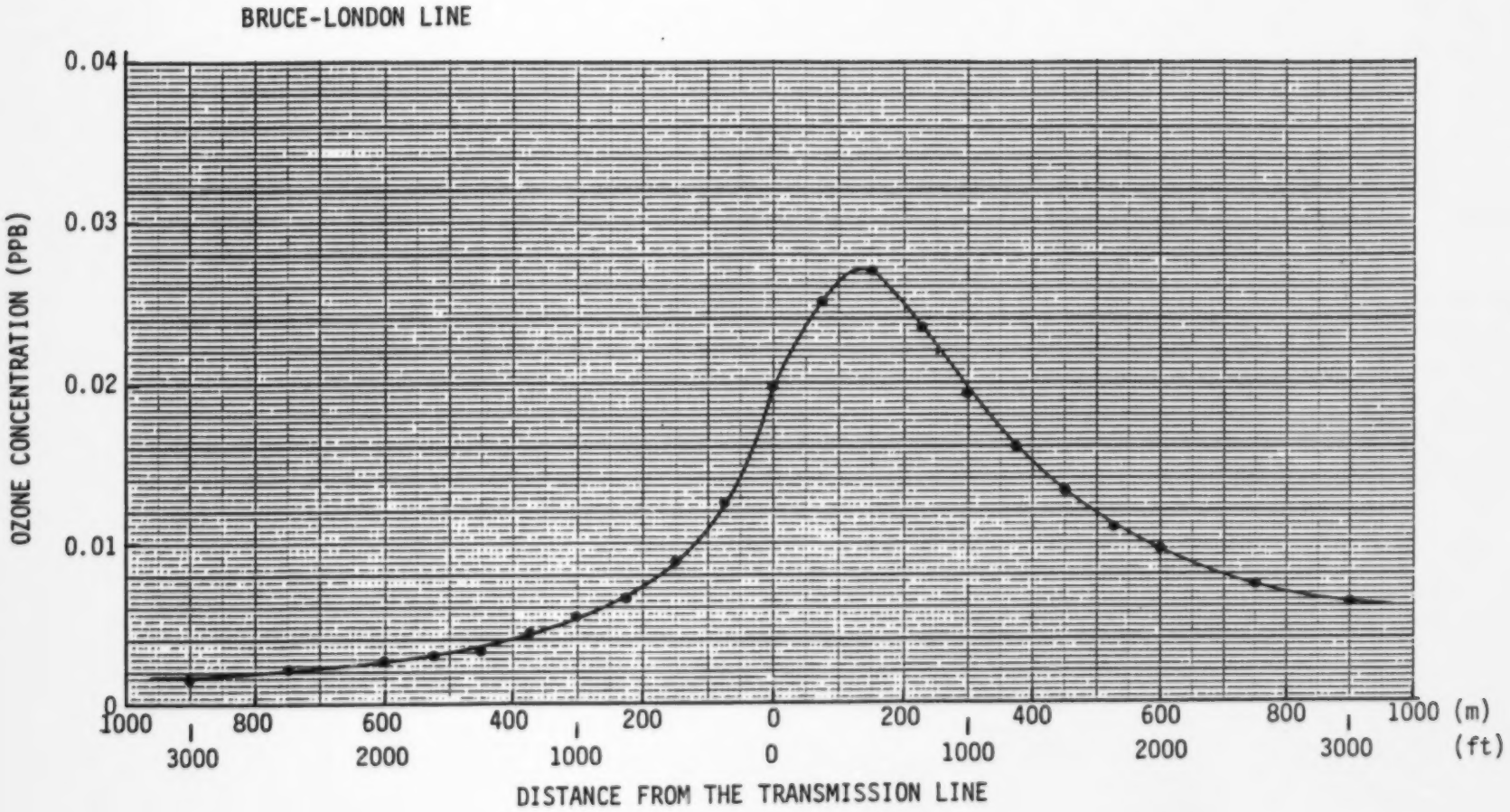

FIGURE A2

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED BRUCE-TO-LONDON TRANSMISSION LINE USING 1979 GODERICH WEATHER DATA

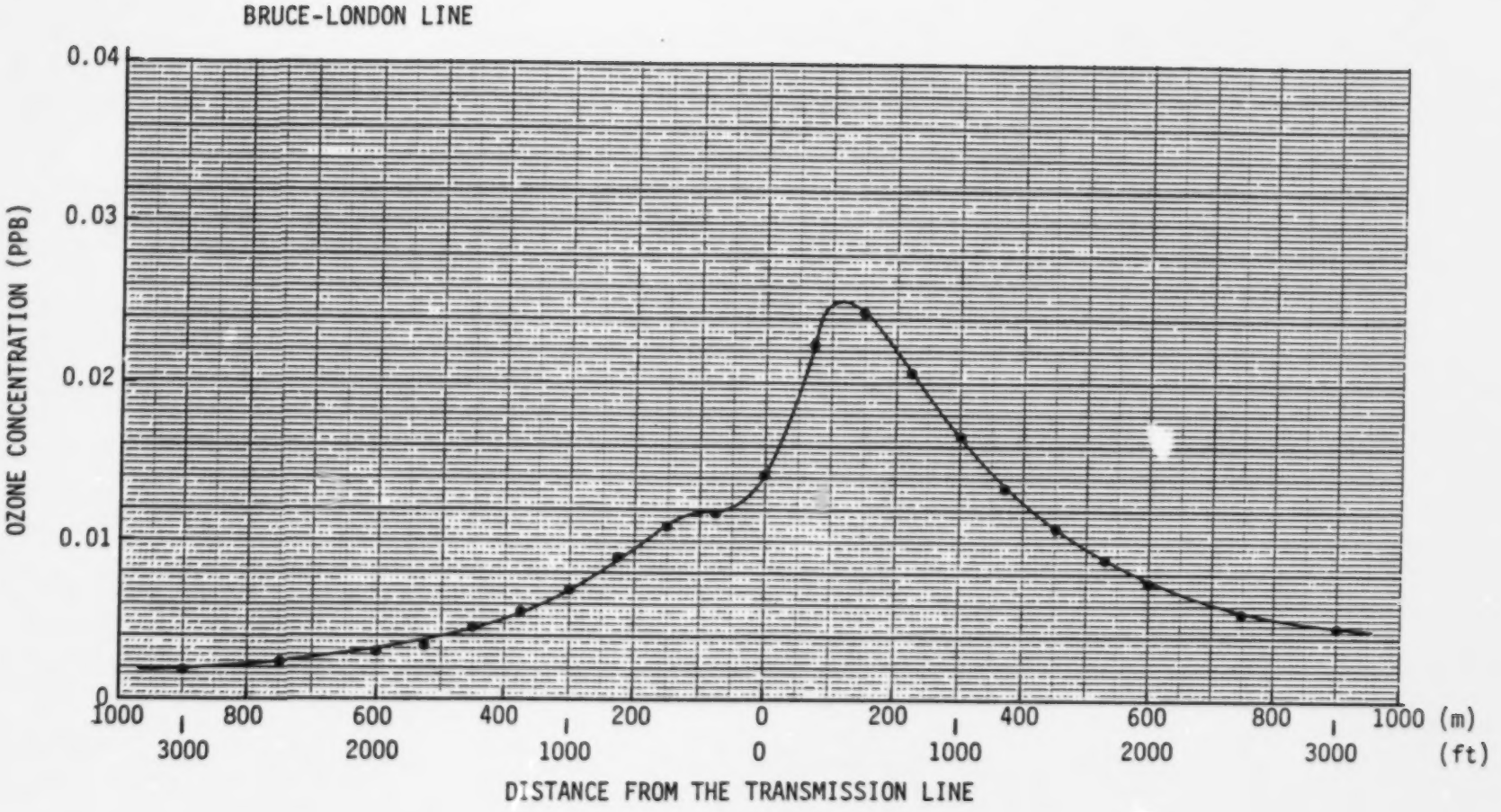

FIGURE A3

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED BRUCE-TO-LONDON TRANSMISSION LINE USING 1980 GODERICH WEATHER DATA

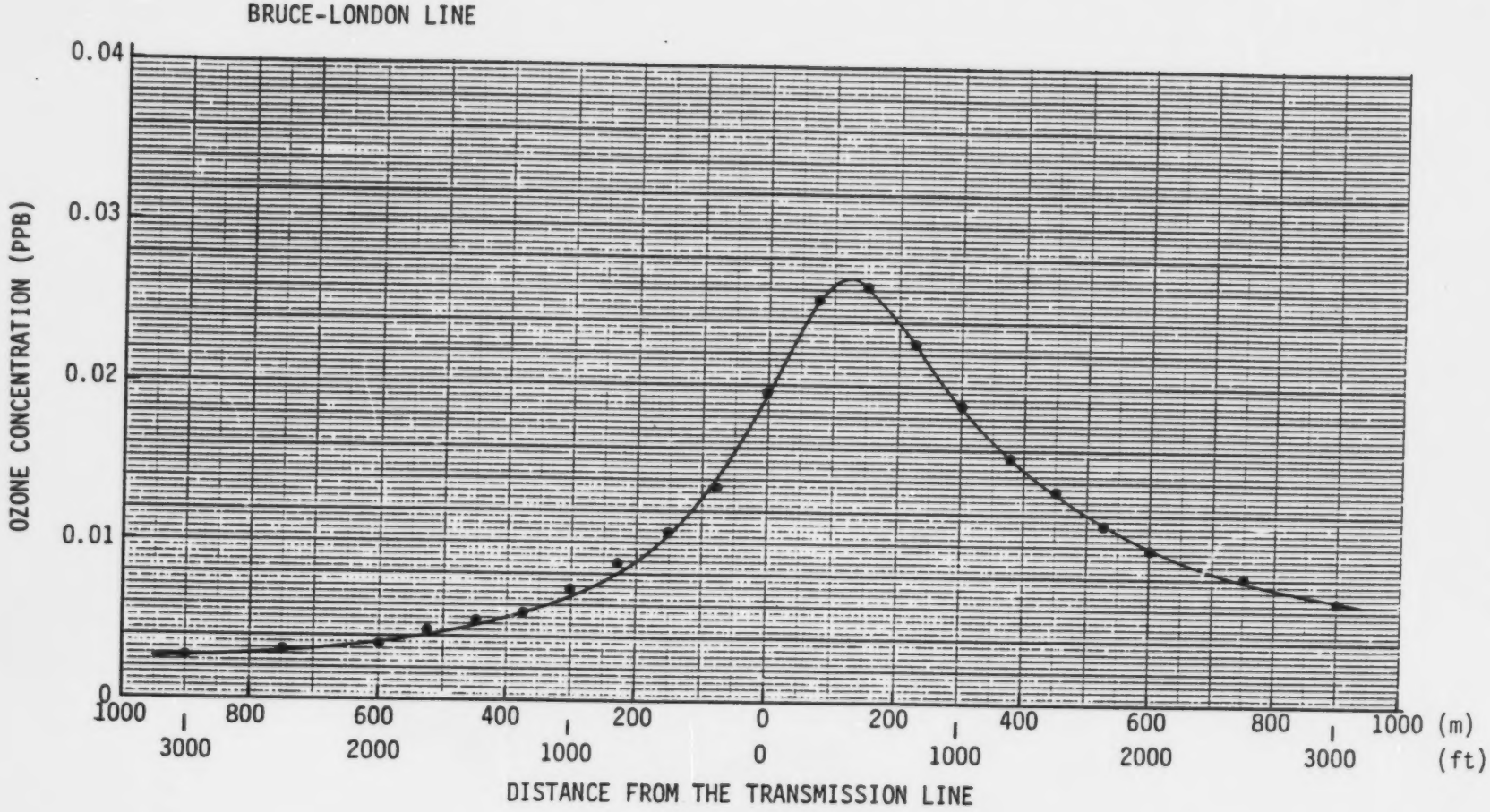

FIGURE A4

THE 3 SEASON AVERAGE CONCENTRATION OF OZONE CALCULATED FOR THE PROPOSED BRUCE-TO-LONDON TRANSMISSION LINE USING GODERICH WEATHER DATA

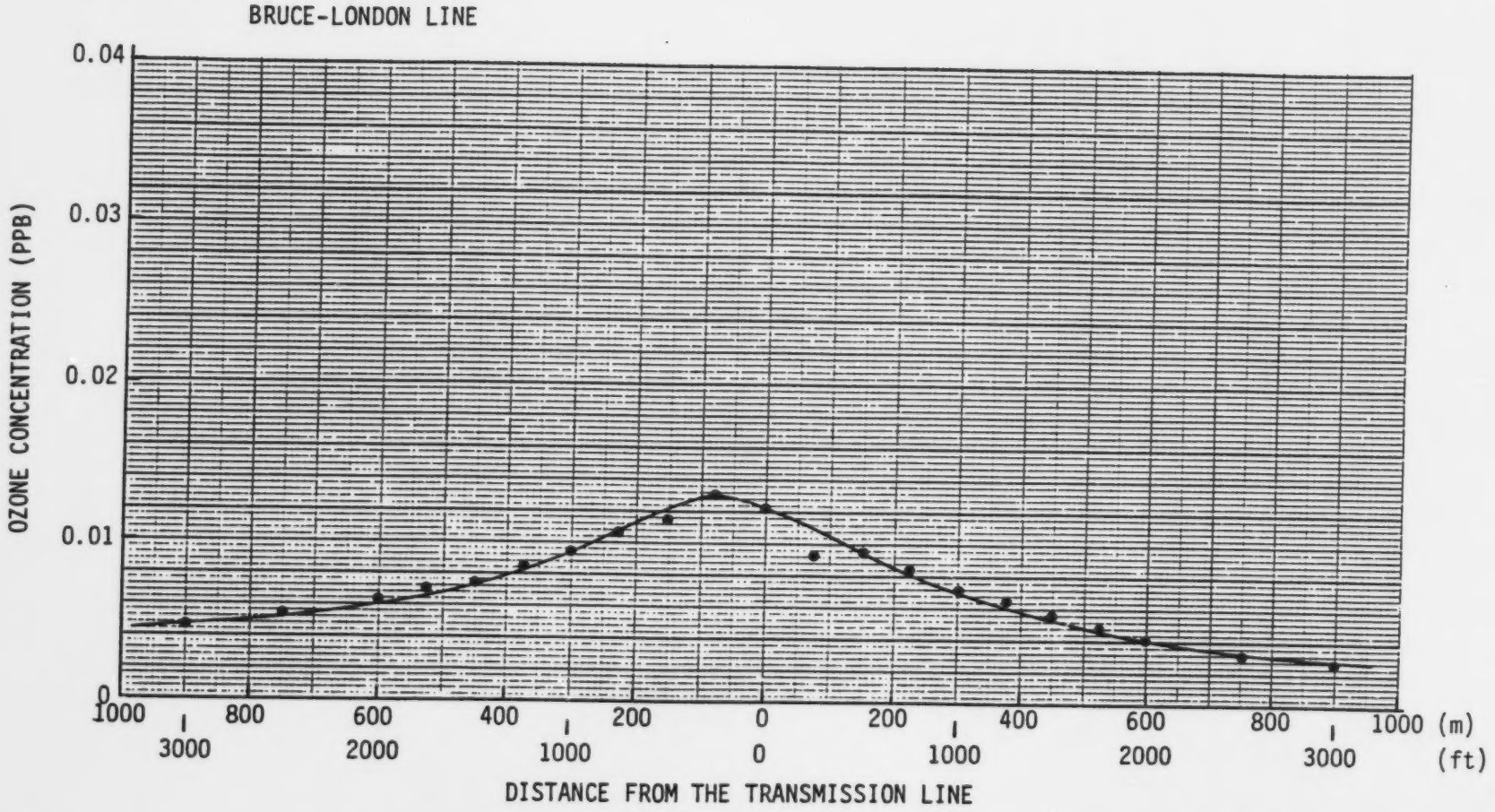

FIGURE A5

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED BRUCE-TO-LONDON TRANSMISSION LINE USING 1978 LONDON WEATHER DATA

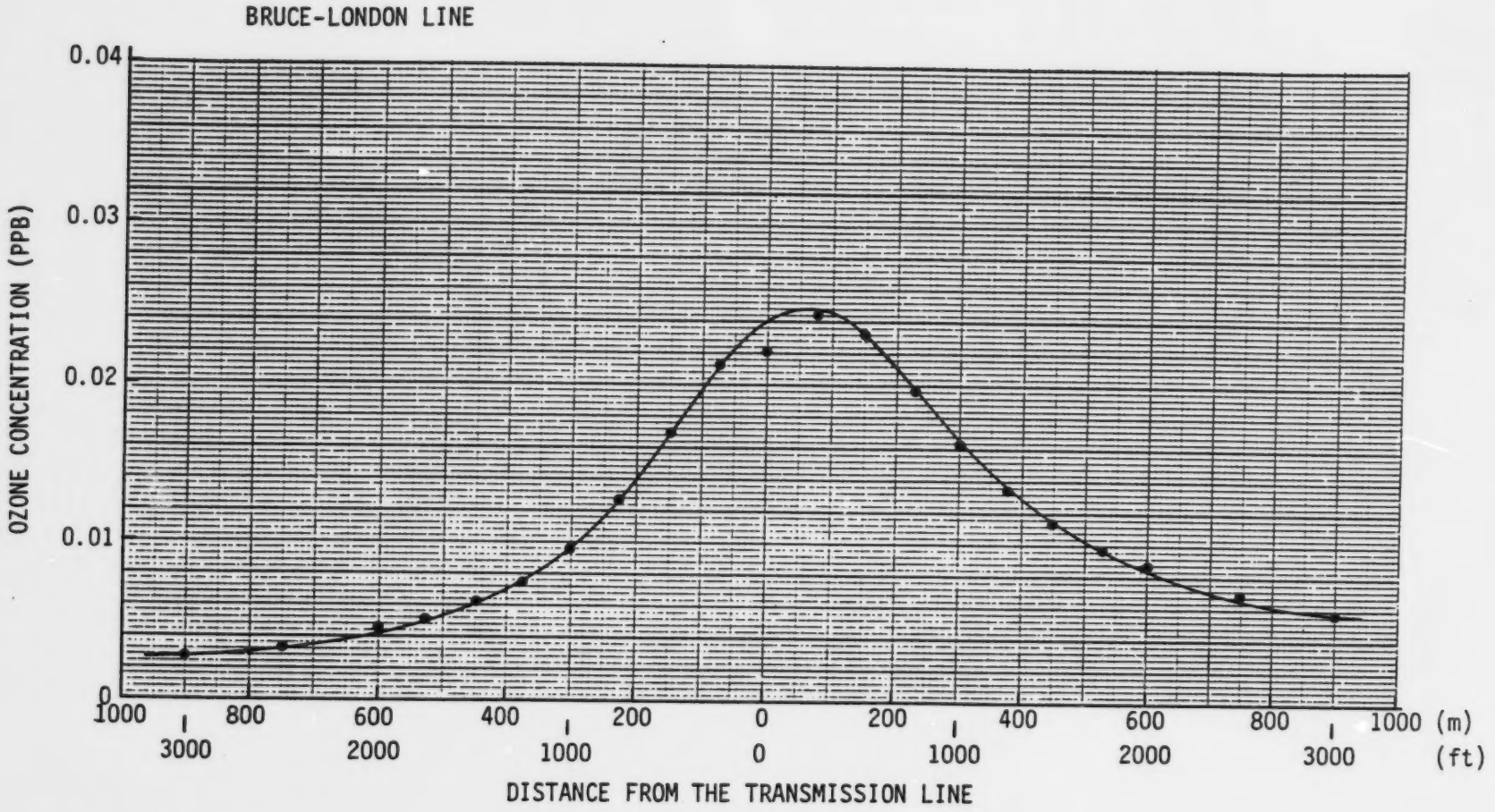

FIGURE A6

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED BRUCE-TO-LONDON TRANSMISSION LINE USING 1979 LONDON WEATHER DATA

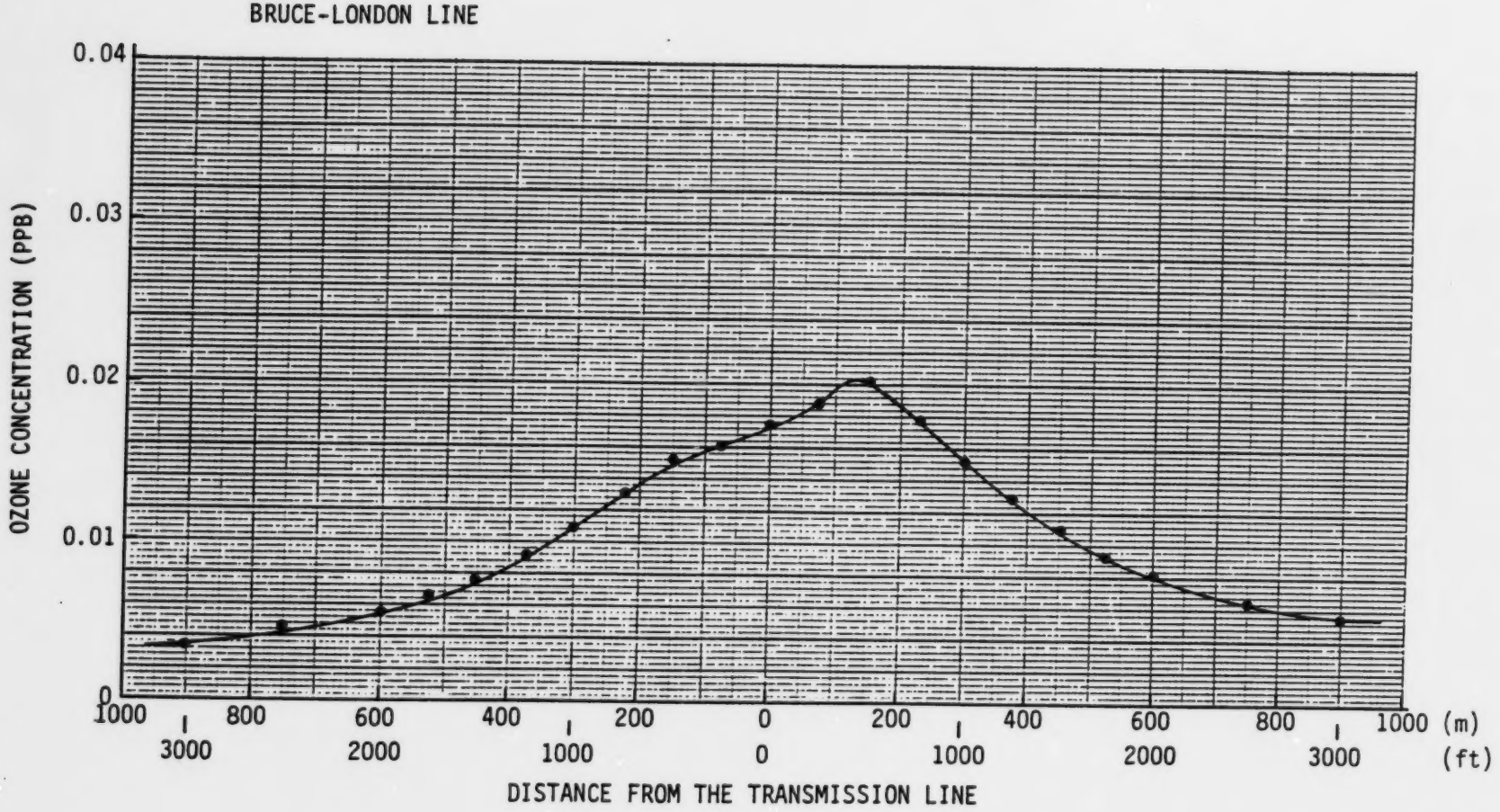

FIGURE A7

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED BRUCE-TO-LONDON TRANSMISSION LINE USING 1980 LONDON WEATHER DATA

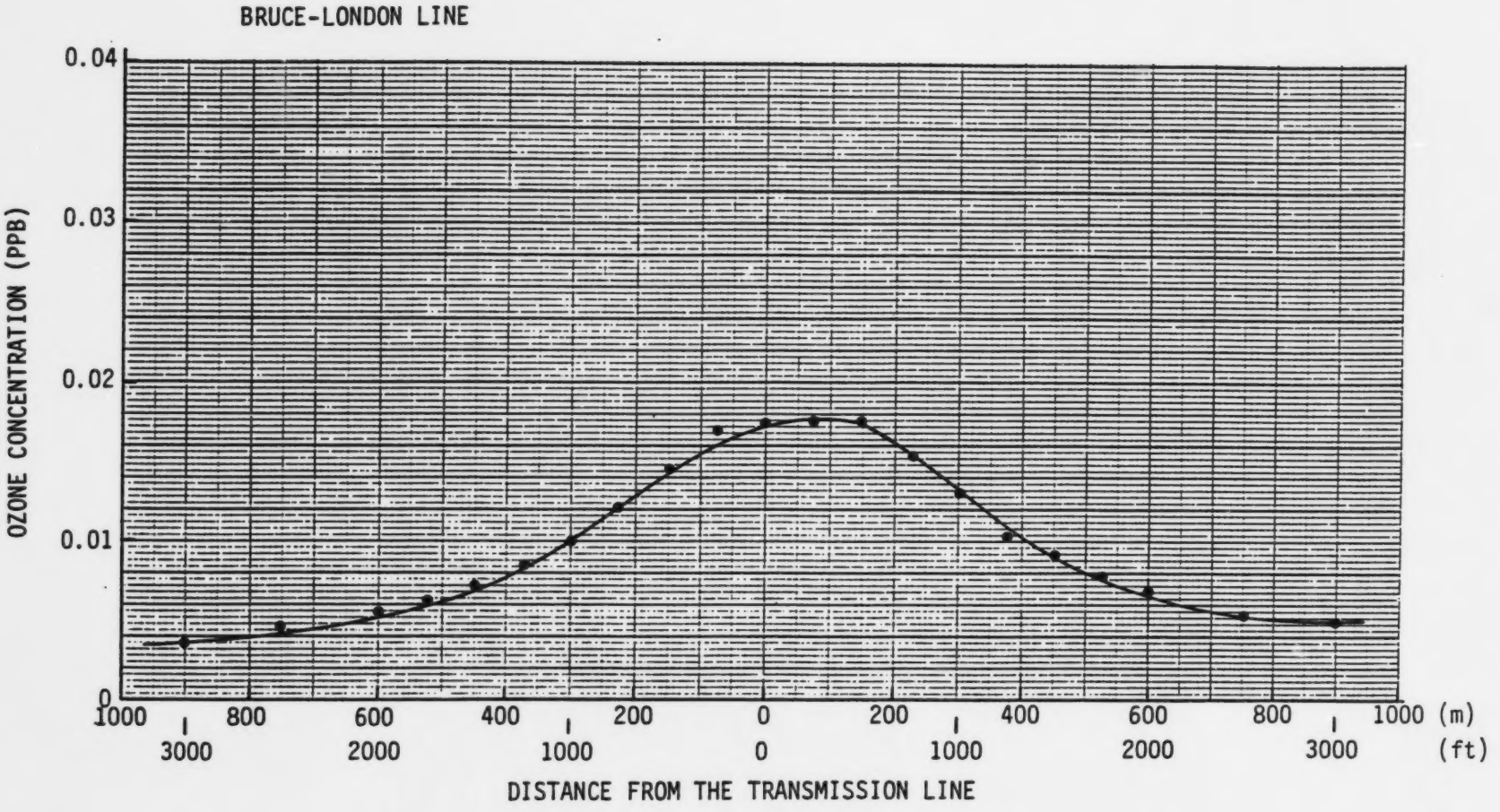

FIGURE A8

THE 3 SEASON AVERAGE CONCENTRATION OF OZONE CALCULATED FOR THE PROPOSED BRUCE-TO-LONDON TRANSMISSION LINE USING LONDON WEATHER DATA

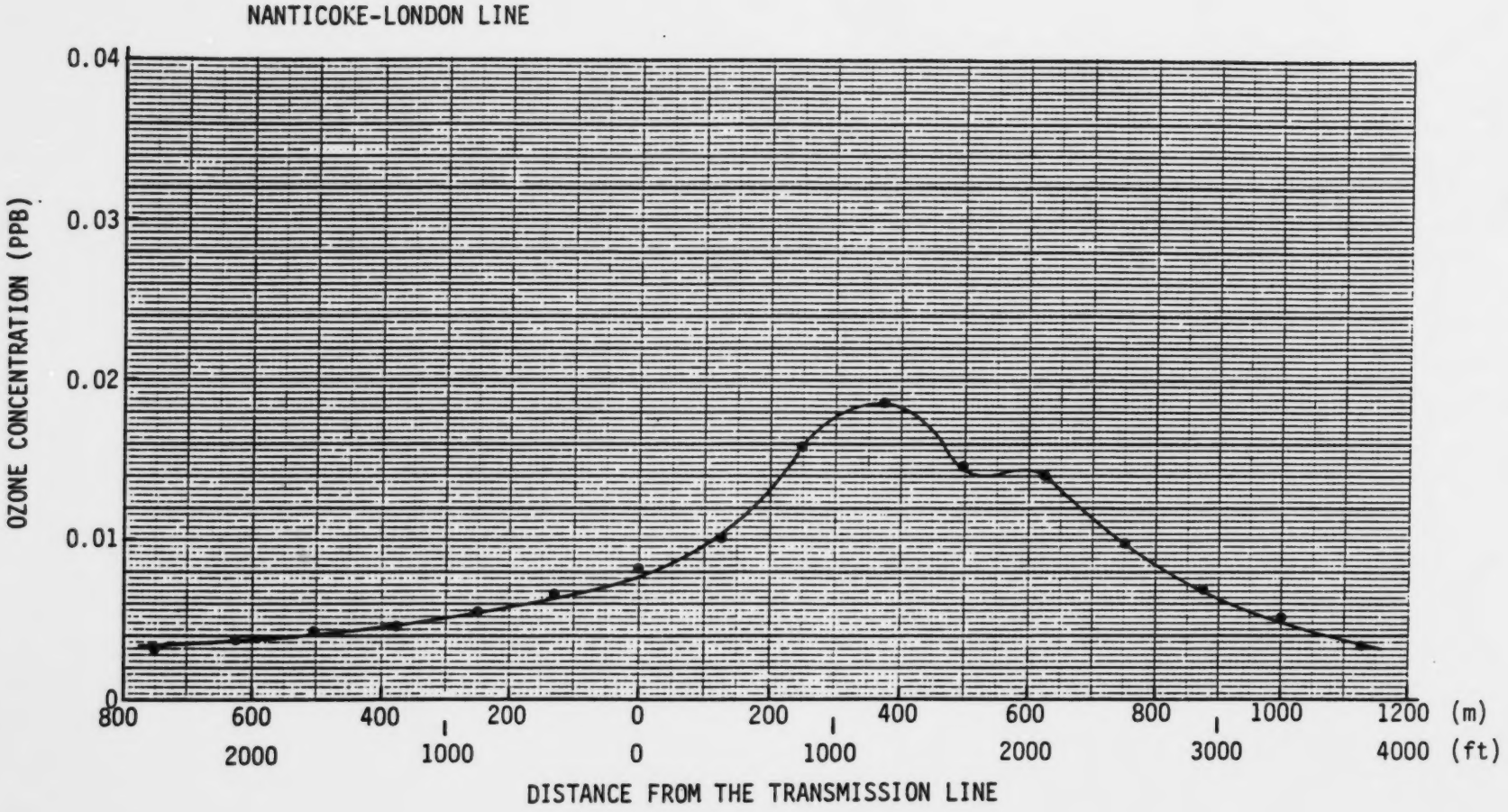

FIGURE A9

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED LONDON-TO-NANTICOKE TRANSMISSION LINE USING 1978 SIMCOE WEATHER DATA

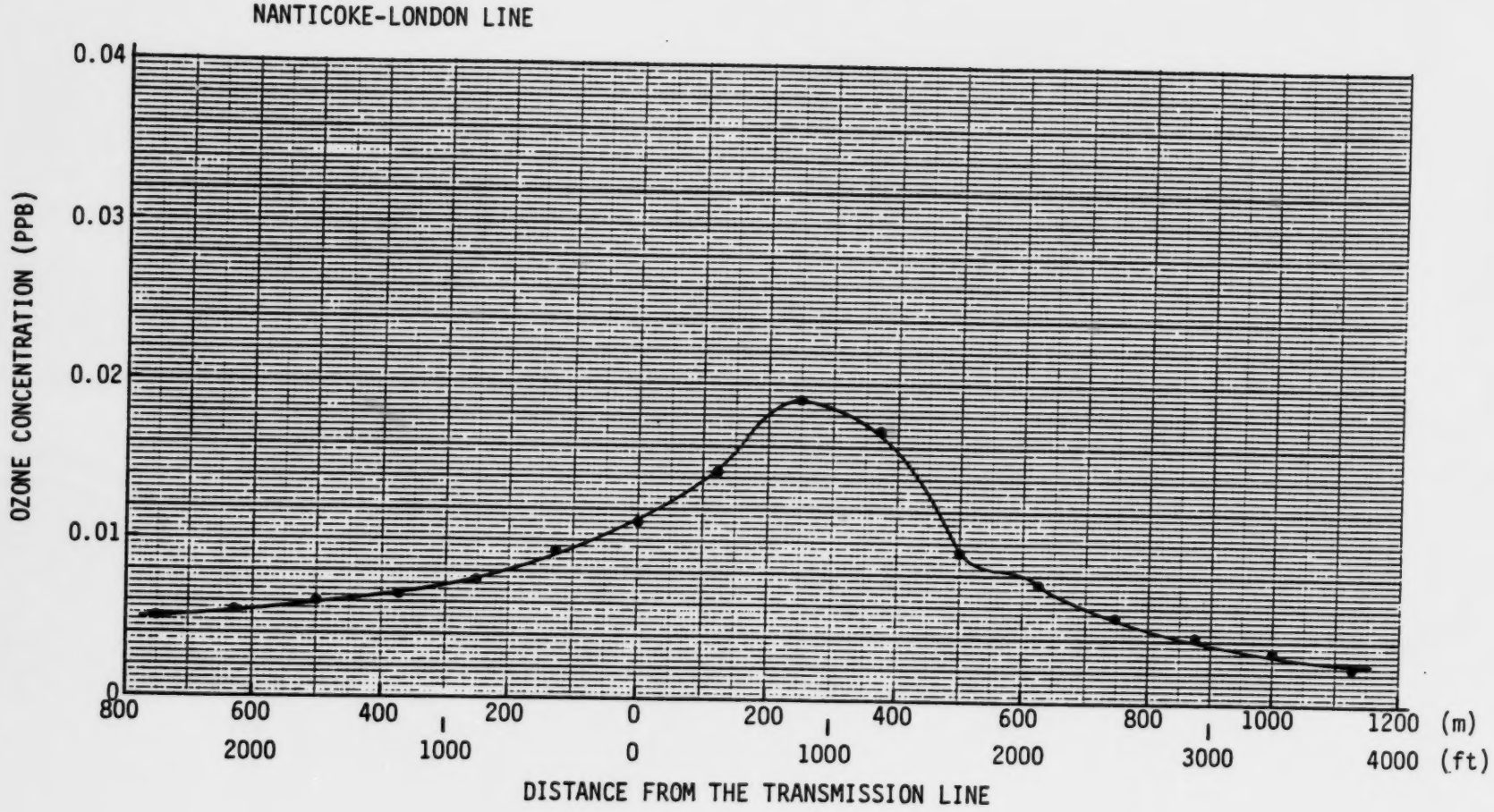

FIGURE A10

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED LONDON-TO-NANTICOKE TRANSMISSION LINE USING 1979 SIMCOE WEATHER DATA

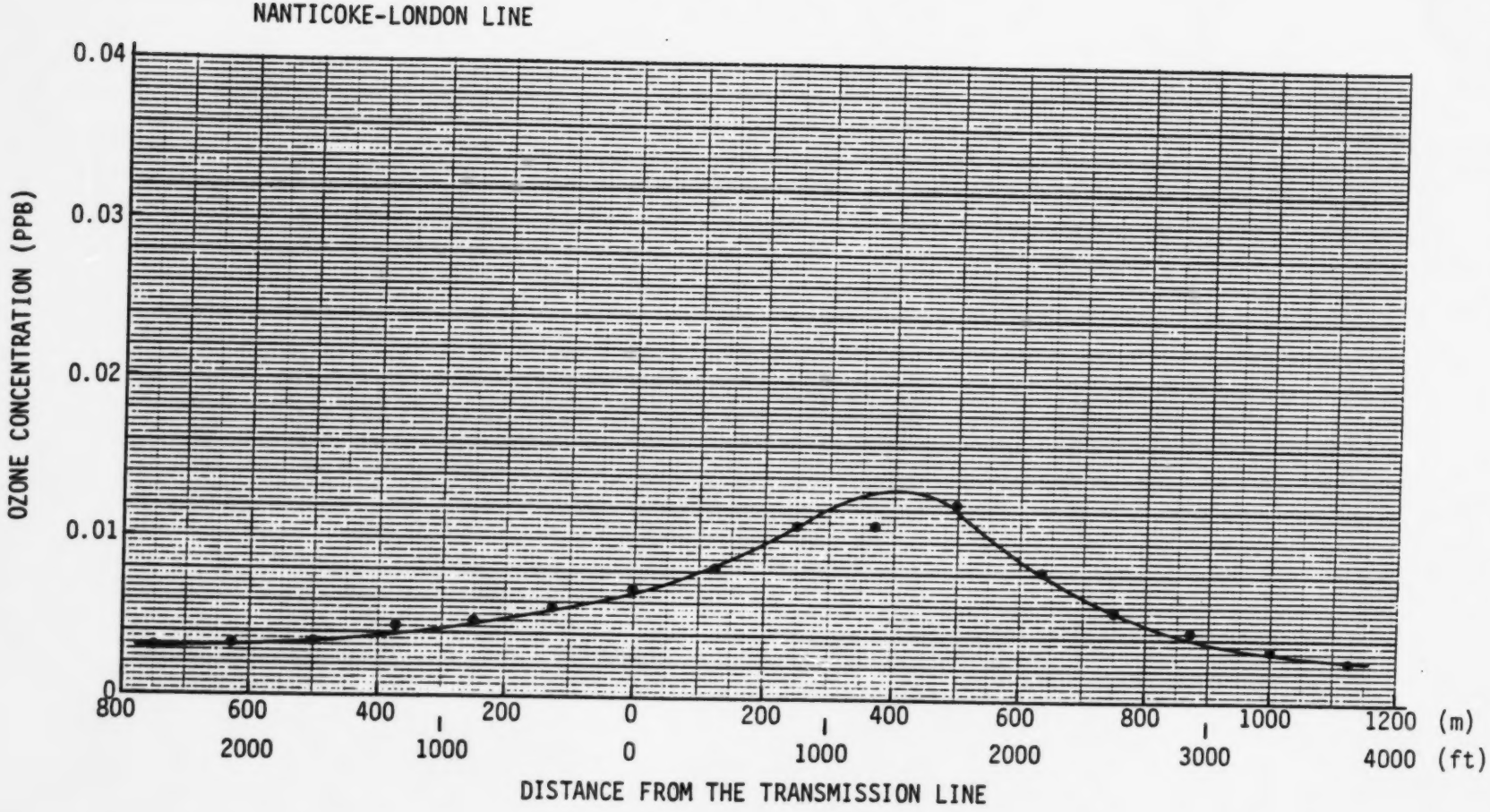

FIGURE A11

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED LONDON-TO-NANTICOKE TRANSMISSION LINE USING 1980 SIMCOE WEATHER DATA

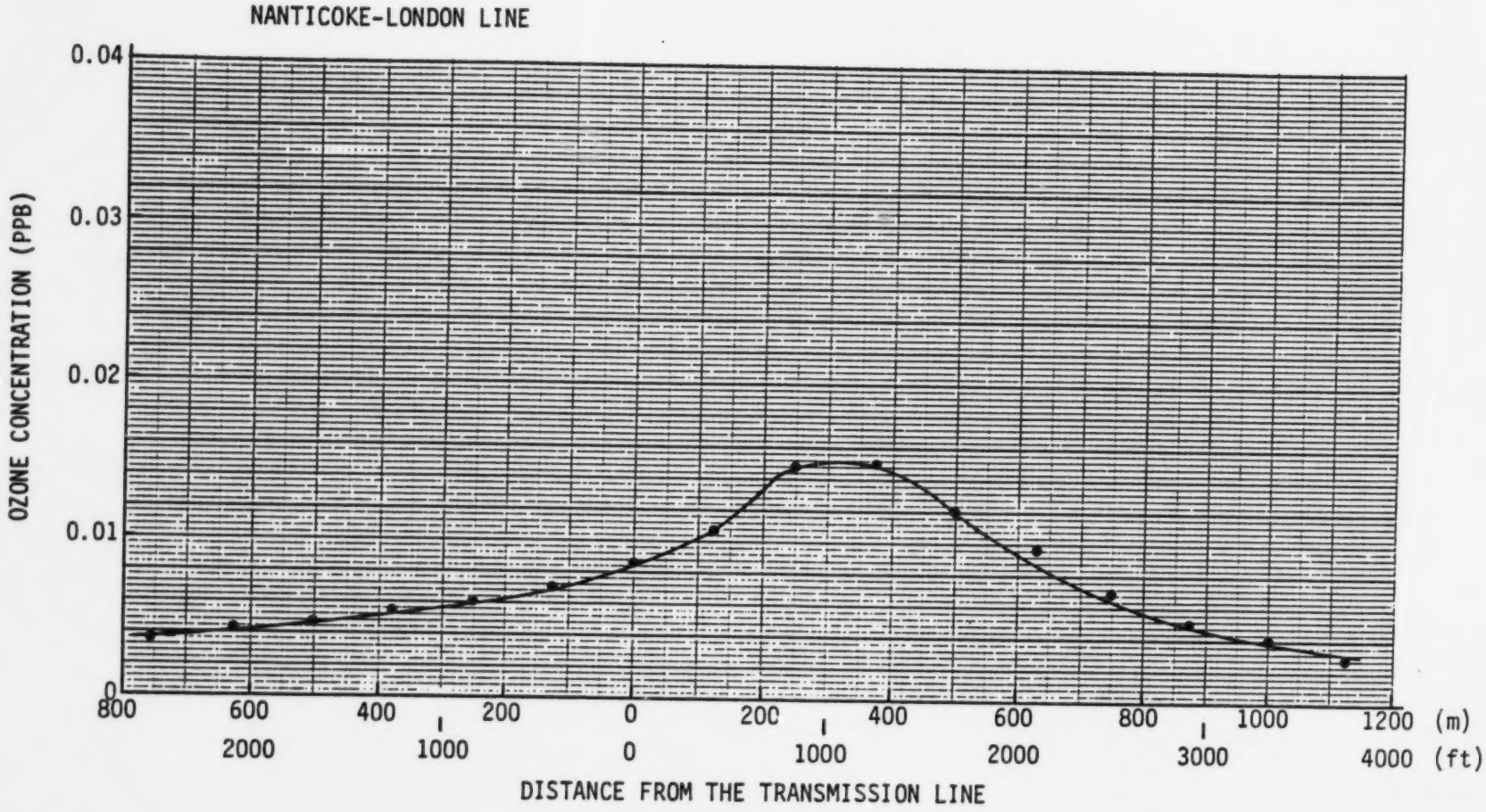

FIGURE A12

THE 3 SEASON AVERAGE CONCENTRATION OF OZONE CALCULATED FOR THE PROPOSED LONDON-TO-NANTICOKE TRANSMISSION LINE USING SIMCOE WEATHER DATA

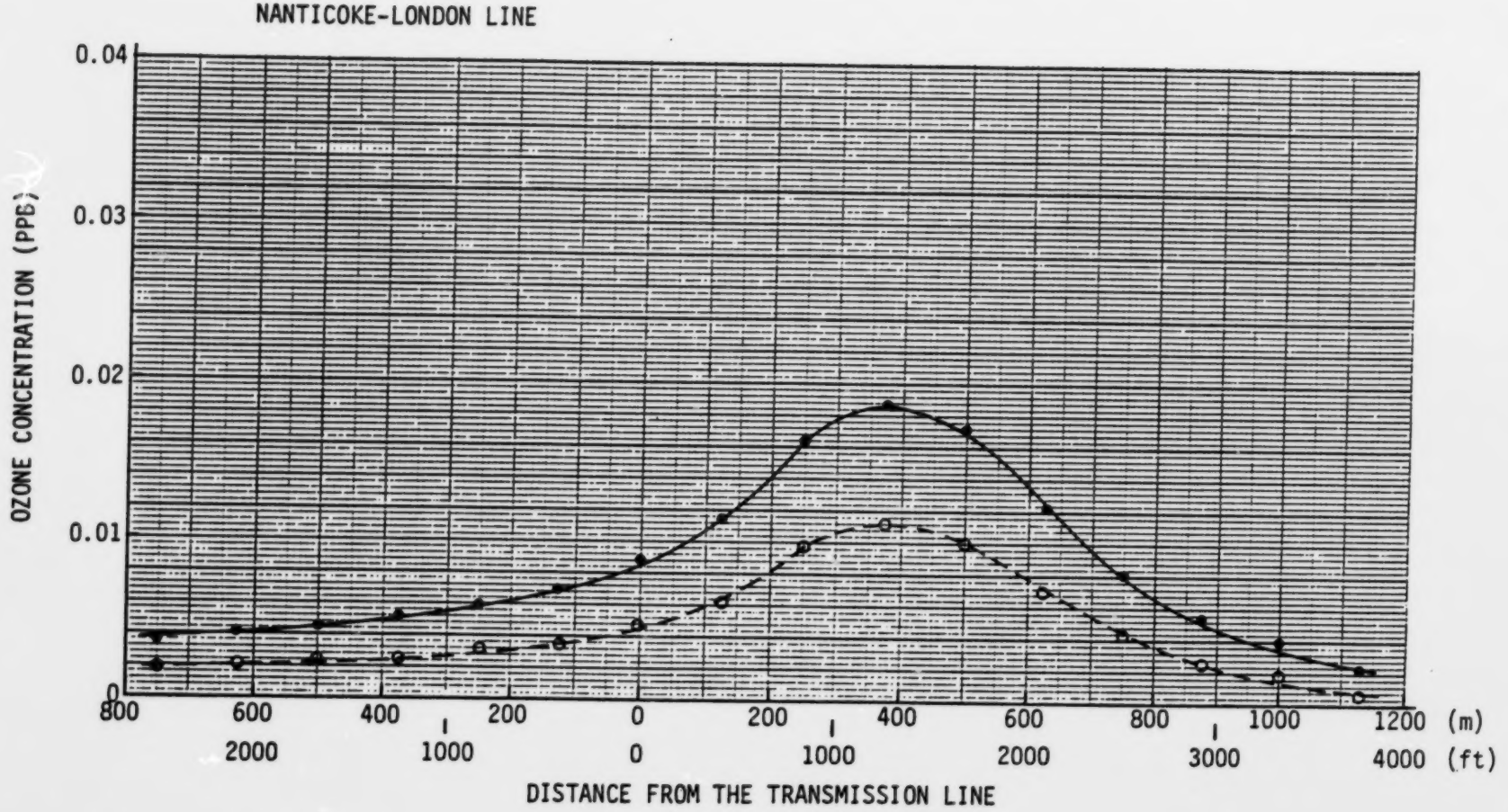

FIGURE A 13

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED LONDON-TO-NANTICOKE TRANSMISSION LINE USING 1978 LONDON WEATHER DATA (THE DASHED LINE REPRESENTS SINGLE-CIRCUIT VALUES)

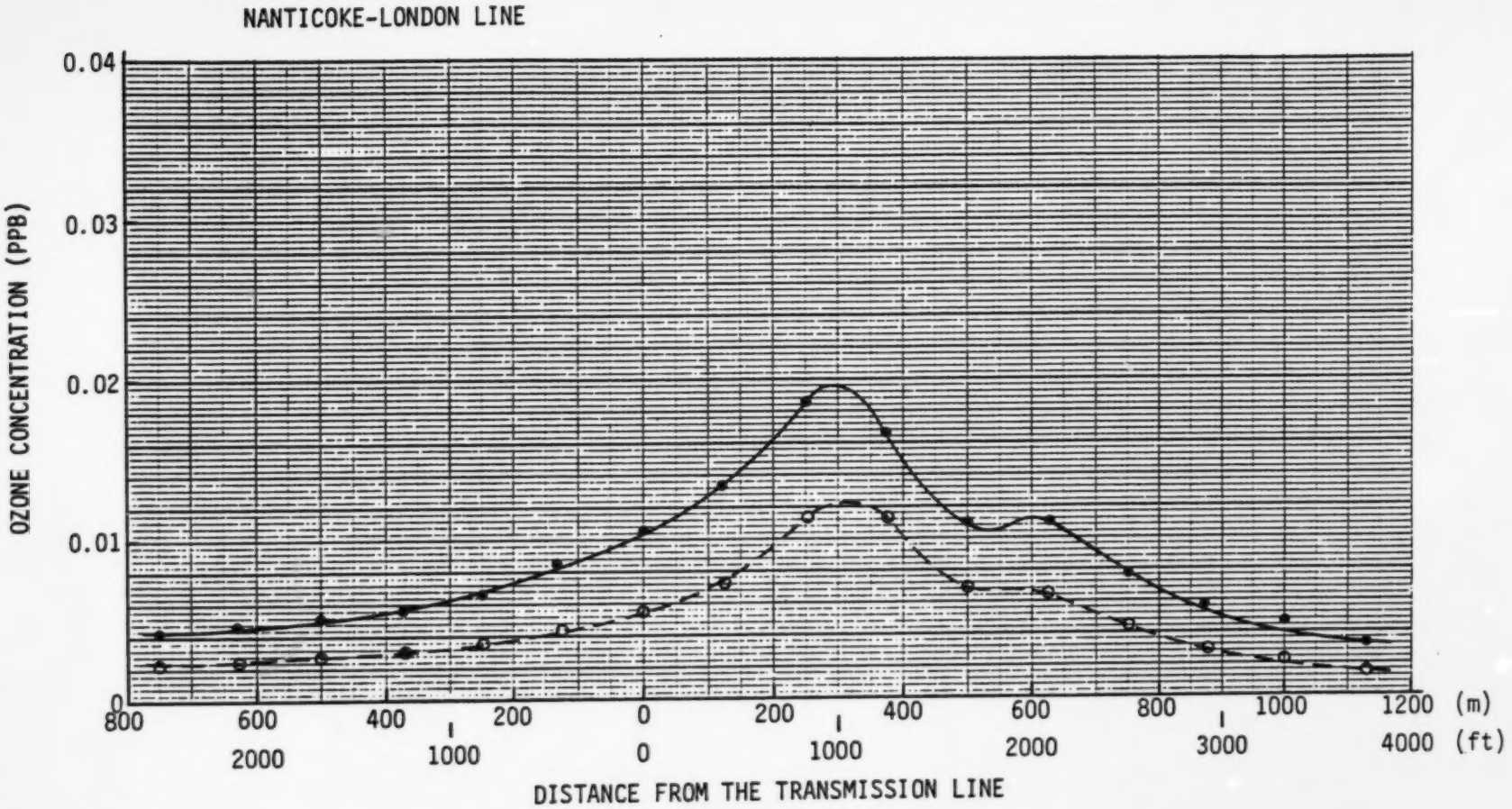

FIGURE A14

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED LONDON-TO-NANTICOKE TRANSMISSION LINE USING 1979 LONDON WEATHER DATA (THE DASHED LINE REPRESENTS SINGLE-CIRCUIT VALUES)

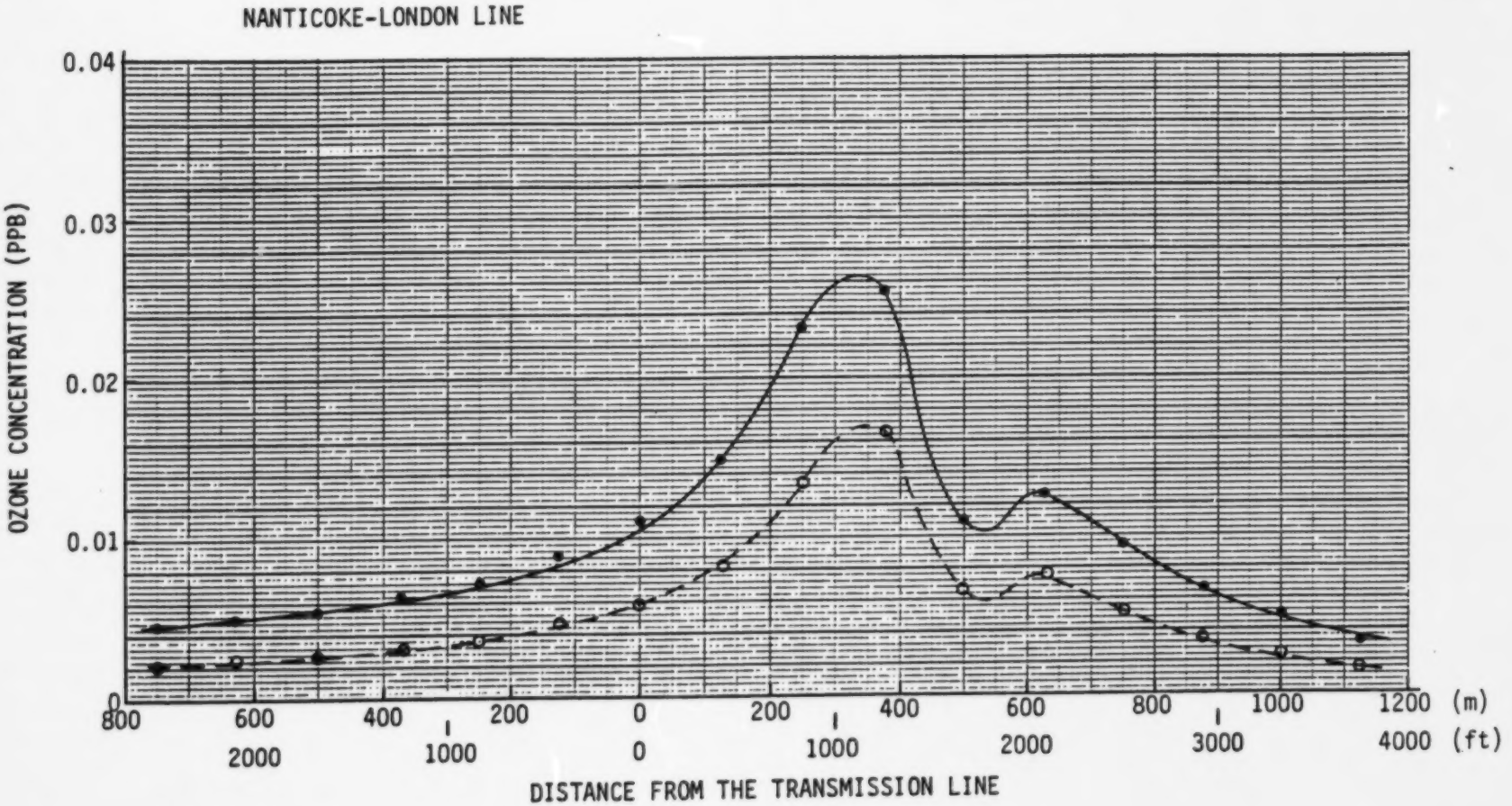

FIGURE A15

THE DISTRIBUTION OF OZONE CONCENTRATION CALCULATED FOR THE PROPOSED LONDON-TO-NANTICOKE TRANSMISSION LINE USING 1980 LONDON WEATHER DATA (THE DASHED LINE REPRESENTS SINGLE-CIRCUIT VALUES)

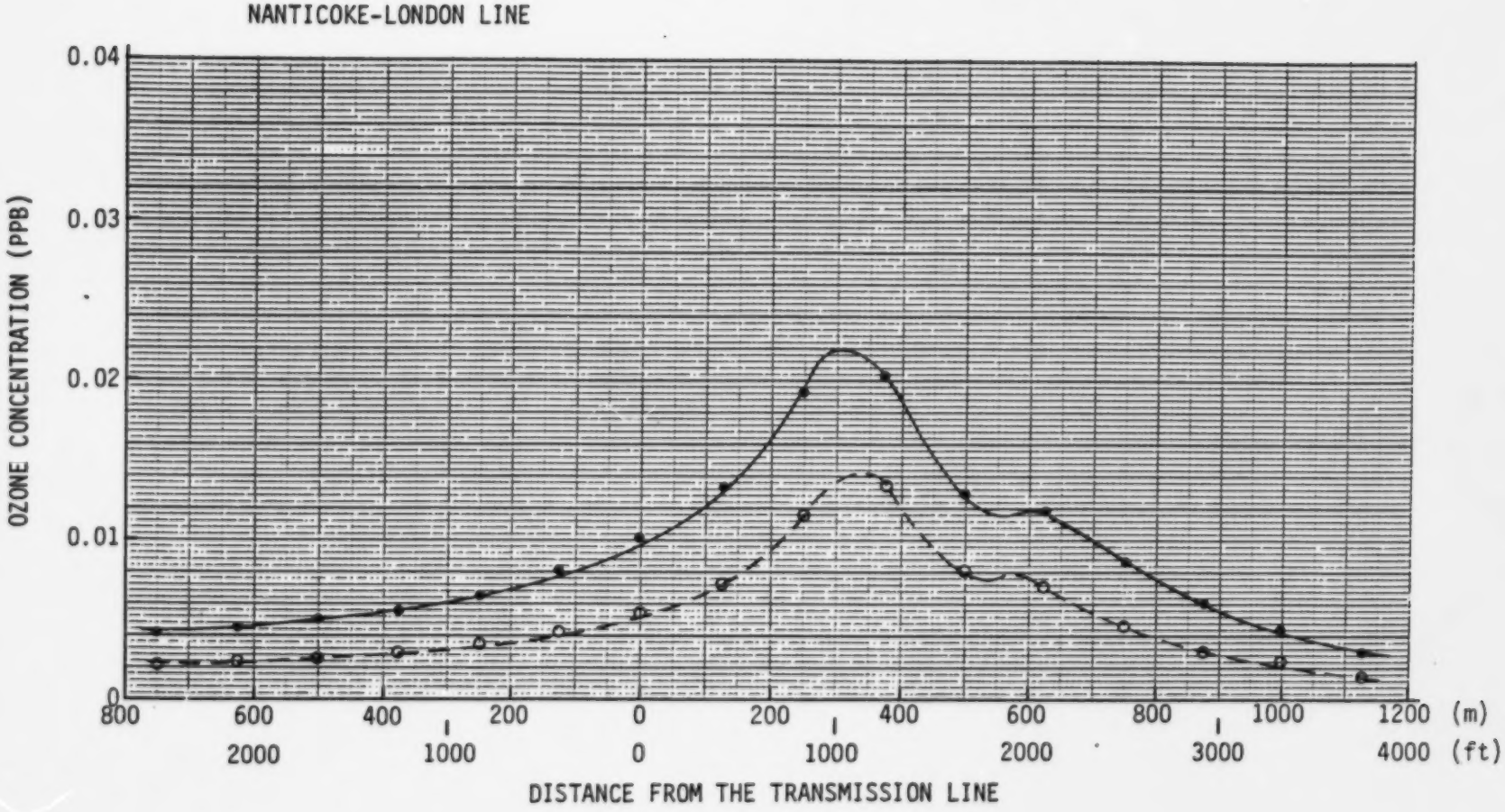

FIGURE A16

THE 3 SEASON AVERAGE CONCENTRATION OF OZONE CALCULATED FOR THE PROPOSED LONDON-TO-NANTICOKE TRANSMISSION LINE USING LONDON WEATHER DATA (THE DASHED LINE REPRESENTS SINGLE-CIRCUIT VALUES)